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Thursday, 17 January 2019

(10.20 am)

MR PENNICOTT: Sir, before Mr Chow continues his questions to Mr Southward, could I just mention one administrative matter or in the nature of an administrative matter.

Sir, you may or may not recall that so far as the COWI report is concerned, the government posed a number of questions in writing to COWI. Those were transmitted to COWI earlier this week, and last evening we received the answers from COWI, for which we thank them.

Just so that everybody is aware of where they are now, they were circulated last evening, I am told, at about 7.40, with the daily bundle update, and they are in tab 4.5 in the expert report bundle.

CHAIRMAN: Good. Thank you.

May I also mention, just for public knowledge, that we've started some 20 minutes late this morning because there were administrative matters that required convening a very brief meeting of counsel. Those administrative matters have now been dealt with and we are able to proceed. Thank you.

Yes, Mr Chow.

MR NICHOLAS JOHAN SOUTHWARD (on former oath)

MR CHOW: Good morning, Mr Chairman and Prof Hansford.

Sir, before I continue with my discussion with

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Mr Southward, may I just raise one point of correction?

Mr Chairman, you will recall that yesterday, at one point, when the Commission was dealing with the test report, at that point I informed the Commission that the Buildings Department was notified of the date of the test and was requested to witness the test. Having taken further instructions, what I said was not entirely correct.

It is still true that the test was not commissioned by the Buildings Department, but the Buildings Department was notified two to three days before the test and were invited to attend, and the Buildings Department was not supposed to validate or confirm the propriety of the testing process. So that is a more description of the position of the Buildings Department.

COMMISSIONER HANSFORD: So their attendance was to witness the test?

MR CHOW: That's correct.

CHAIRMAN: Thank you.

Cross-examination by MR CHOW (continued)

MR CHOW: Good morning, Mr Southward.

A. Good morning.

Q. I still have some more questions for you, if I may. I would like to finish off the slides first, because yesterday I had been discussing some of the slides that

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you have produced to assist the Commission.

May I ask you to go to page 19 of your slides, regarding Atkins' calculation. Yesterday, you said that -- if I may just quote what you said -- for the purposes of the record, it's yesterday's transcript page 119, starting from line 6 -- you said:

"So there are some aspects of this calculation that I don't fully understand. It's handwritten and so clearly it would be good to have a discussion with the actual engineer by himself who wrote that. But if this is the approach they have used, then this is very conservative, and it would certainly demonstrate compliance for both change 1 and for the issue of horizontal shear stresses for change 2."

Mr Southward, have you had a chance to look at Prof Au's report, in particular his comment on Atkins' calculation?

A. Yes, I have read his report.

Q. I understand that Prof Au's criticism actually relates to four aspects of the calculations; do you recall that?

A. Yes. Well, I can't remember the number, but yes. He was critical of those calculations, yes.

Q. I'm not going to ask you for details, but am I right to say that basically you don't agree with Prof Au's comment; is that right?

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A. Well, I look at this calculation, which takes a bending moment and divides it by the lever arm between the top and the bottom of the wall section within the EWL and turns that into a shear force, and if -- and then there's a calculation for that shear force, for the capacity based on that shear force.

And if that calculation is correct, then that is a very conservative approach because there can't be any more shear force. That shear force doesn't really exist, because there's solid concrete going out on one side and a third of the way out on the other side.

So to consider the wall in isolation is really very conservative.

Q. Right. Fine.

A. So that was my opinion.

Q. I think all I need to do is just to register the government's disagreement on that and I will move on; right?

A. Sure.

Q. Can I now refer you --

COMMISSIONER HANSFORD: Sorry, Mr Chow, why does the government disagree on that point?

MR CHOW: Perhaps I haven't made myself clear. What we do not necessarily agree with Mr Southward is in relation to the propriety of the way it was calculated. We rely

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on the evidence of Prof Au, the criticism raised by Prof Au in his report. It is to that extent that we cannot agree with Mr Southward.

COMMISSIONER HANSFORD: Yes. Okay. Thank you.

MR CHOW: Mr Southward, can I refer you to page 21 of your slide, where you talk about dowel action resistance.

If I may then refer you back to yesterday's transcript at page 120, starting from line 3, where you talked about the dowel action and the slide showing the yellow block. Do you recall that?

A. Yes.

Q. You said:

"Looking at a close-up detail of the yellow slice, we can see there are two layers of T50 vertical bars and two layers of T40 bars that cross this interface. So these are the vertical bars drawn in black. Two of those bars are T40 bars and two of those bars are T50 bars.

There is so much reinforcement, in fact, that the basic shear capacity of the steel bars in dowel action alone is enough to resist the tension load developed in the horizontal T40 bars at the top of the slab. So you can see the red arrow which is -- that's the tension force in the T40 bars, and that is pulling the yellow slice to the left. That pulling is basically resisted

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by the steel bars. The steel bars would have to be sheared. The steel bars would have to break in order for the yellow slice to move."

Can you see that?

A. Yes, I can.

Q. My question is this. The T50 bars that you are talking about are the vertical bar on your slide; is that correct?

A. Yes. I recall that the two bars closest -- the two vertical bars closest to the right are the T50 bars, and inside, the third bar is the T40, and then on the other face, on the left side, it's a T40 bar.

Q. So the dowel bars that you refer to are the vertical black bars?

A. Those are the main steel reinforcement in the diaphragm wall.

Q. Do you agree that to be able to mobilise the dowel action, one has to ensure that we have adequate anchorage length, that is the portion of the vertical bar inside the yellow block?

A. Not -- no. No. I don't agree with that. Would you like me to explain or --

Q. Yes, please.

A. Let's take Prof Yeung's slide yesterday. The very last slide was an example of a bolt with two plates moving

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apart. If we can see that slide, that would be the easiest.

So this top -- the slide on -- the image on the top right-hand corner, you will see there's two plates, and there's a bolt that goes through the middle of those two plates.

Q. Yes.

A. Now, that bolt has got a rounded stud on the top and a rounded stud on the bottom. That is drawn diagrammatically, I guess, as the nut and the head of the bolt.

Now, if you took the nut and the head of the bolt off, if you removed the nut and the head of the bolt, there's no anchorage to the bit of bolt that's in between the two plates.

Q. Yes.

A. So there's no anchorage. But I'm sure you would agree, that bolt is still working, it's still there, working in dowel action.

Q. Right.

A. So that's why I say that you don't need the bolt to go 400 millimetres up, above the top plate. You don't need it to be anchored, because dowel action is just the action of (demonstrating with a pen) this pencil breaking, being sheared sideways.

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Q. Thank you.

Then if I may go to your expert report.

Mr Southward, do you know Mr John Blackwood of Atkins?

CHAIRMAN: Sorry, could I just ask one question there, to go back. I appreciate the point you're making, that you've got the bolt -- it may not have the top and the bottom but it's still there, and so on a straight shear force basis it's still operating, even though it's not anchored.

But would shear force operate together with some form of other dynamic, such as vertical force, which might then, because that bolt is not anchored, lift the bolt in some way or drop the bolt in some way, and then allow the shear force to operate?

A. Well, okay. In the example on the screen, if you took the head of the bolt and the nut of the bolt off, there's a chance that the bolt might fall through because there's nothing below it. But in this case, there's a concrete diaphragm wall, so the bars aren't going anywhere.

CHAIRMAN: Yes.

A. What other complementary actions there are -- I mean, Prof McQuillan showed us in his sketch a vertical load that was clamping down on that interface. Okay, that's a representation, but there was that vertical load.

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The purposes of that sketch was to provide a response or to say that that free body diagram does work, and in that free body diagram there are no other forces acting.

CHAIRMAN: Of course. I suppose my question then is, using the words that you use so much better: when you are looking at shear force and on a day-to-day design basis, you presumably don't look at that in isolation, you look at complementary forces?

A. That's right, so there's axial load, there's bending moments and there's shear. So outside of the diaphragm wall, at the junction of the wall and the slab, there are bending moments, shears, axial loads. So those are complementary.

In this particular case, in this horizontal slice, we are just talking about shear, and that's the concern of Prof Au, the shear stresses across that joint.

CHAIRMAN: Thank you.

MR CHOW: Mr Southward, can I just quickly clarify one more thing regarding the dowel action. Am I right in thinking that the dowel action actually is comprising of two elements? The first element is because of the dowel bar, if there is sufficient anchorage, then it will generate a compressive force between the concrete surface, and that compressive force will mobilise the

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shear resistance, the friction between the concrete surface. This is one element of the dowel action. Do you agree or --

A. Sorry, that --

Q. That would be one component of the dowel action?

A. I don't -- can you repeat again clearly? I can't --

Q. Because of the dowel bar, when it is subjected to shear motion, then it will mobilise tension within the dowel bar, and the reaction will be resisted by -- will exist between the concrete surface that the dowel bar tries to connect together?

A. There will be some -- are you talking about the bearing stresses in the steel bar against the concrete? Is that what you are referring to?

Q. That is the second component that I am going to. But do you agree with me that the reason why dowels can help to resist lateral movement, part of the action actually goes to the fact that it will mobilise the friction between the two concrete surfaces?

A. Well, there aren't two concrete surfaces. Here, it's one monolithic piece of concrete. There is only this artificial construction joint that has been properly prepared and made ready so that, in the eyes of design, it's no longer a construction joint because it's become a monolithic piece of concrete.

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Q. But that is your assumption. Your assumption is that --

A. Well, it's reality, that's what happens.

Q. -- the construction joint was properly prepared, the surface of the construction joint was properly prepared before casting of the new concrete. This is your assumption.

A. Well, okay -- I was not on site at the time of the preparation of the construction joint, so yes, I did not see with my own eyes that the construction joint was prepared in accordance with the specs. No, I didn't. But I am told that it was prepared so I can only rely on that.

Q. Later on I will take you to some of the photos, but for the present purpose, so you agree -- do you agree with me that this is one of the components of --

A. Sorry, you will have to go back to "this is one". What is "this"? You said "this is one of the components" -- can you just remind me what "this" is?

Q. The dowel bar will mobilise the friction between the two concrete surfaces to resist the shear force?

A. The dowel bar will mobilise the friction between the two -- no, I don't understand that.

Q. Fine. The second component is the one you have just mentioned, make use of the dowel bar and that will generate bearing stress on the concrete surrounding the

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dowel bar.

A. Yes.

Q. Have you checked whether -- you mentioned about there are lots of reinforcement, T50, T40, to be able to work as a dowel bar -- have you checked the stress generated on the surrounding concrete, to make sure that the concrete can withstand the stress?

A. No, I have not.

Q. Thank you.

CHAIRMAN: Do you think you should have done? That's I suppose the natural question.

A. Well, I mean, I've had limited time. I think if one really needs to do that calculation in Prof Au's way, you actually need to look at a much bigger picture, because looking at this little yellow slice, it's physically impossible for it to move, and that is actually evidenced by reality because it's not moved.

So if you were to do this kind of check, you would look at the whole element. Maybe perhaps -- can I draw and show you?

CHAIRMAN: Of course.

A. (Drawing on the whiteboard) I think, from recollection, it's something like that, isn't it? The D-wall comes up and then it goes like that, and there's all that reinforcement there and then there's reinforcement here,

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and then we've got reinforcement that comes down there and we've got reinforcement that comes here and across here, I think.

I've run out of colours, but Prof Au is saying we need to be looking at the stresses across that interface there (indicating red dotted line) in isolation, by itself, and really, that slide, it can't move. Well, it hasn't moved and it can't move. But if you did want to look at things moving, you would look at that section (drawing blue dotted line) all the way.

Maybe, actually, if you could look at the slide on the screen, you see the way the structure -- in fact, I think there were two -- this slide and also the slide before shows how -- that when things are struck together, they bend, but when things aren't stuck together they bend independently.

COMMISSIONER HANSFORD: That's it.

A. Yes.

So if when looking at this slab (indicating) and this slab is being bent downwards, then we could imagine that there was a slice all the way along here (extending the dotted red line). So imagine that line is one of the lines on the slide.

So you would have to check that the whole plane didn't slide, not just one small plane.

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Does that make sense?

CHAIRMAN: Yes, it does.

COMMISSIONER HANSFORD: Two supplementary questions, Mr Southward.

Firstly, is that something that could be done with finite element analysis?

A. Yes, I'm sure. Yes. I mean, if you did a finite element analysis of this thing, you would see exactly where all the stresses went and the flow of shears and everything.

COMMISSIONER HANSFORD: The second question is: do you think that's necessary?

A. Not really, no.

COMMISSIONER HANSFORD: Thank you.

MR CHOW: Mr Southward, in fact this very point has been raised by Mr Shieh with Prof Au, and Prof Au has explained how the concrete failed under --

A. Sorry, which point?

Q. About the whole slice has to move.

A. Yes, he --

Q. Can I finish my question first, then you will have a chance to respond.

And Prof Au explained to the Commission that when the concrete within the connection starts to fail because of the shear and cracks will develop at the new

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interface, and after that there may be other cracks develop vertically on the two sides of the diaphragm wall. This is how Prof Au explains to the Commission.

So Prof Au is not anticipating that the whole horizontal slice of the whole EWL slab would slide, and he considers cracks developing in that way, the concrete is considered to have failed. What is your response?

A. But he sat here and said that this bit up here is going to slide and we need to check to make sure it's not sliding. That's what he said.

I believe there was talk about -- well, okay, I mean, it was three days ago now -- but I think he was talking about the subsequent signs of distress, what might happen afterwards and the cracking, but that's just a guess. I can't remember.

Q. All right. Let's move on then.

A. Okay.

Q. Mr Southward, just now I've asked whether you know Mr John Blackwood of Atkins.

A. I have met him maybe once or twice. I think maybe five or six years ago I was on the Association of Consulting Engineers council and I can't remember whether Mr Blackwood was a member there or not. But I met him a couple of times, but not more than that.

Q. All right. Don't worry about it.

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The reason why I ask is because Mr Blackwood gave evidence to this Commission, and from Mr Blackwood's witness statement, I understand he is also a very experienced engineer. He is a director of Atkins.

Now, when it comes to the question of whether the second change needs to get prior consultation with BD, he said in paragraph 98 of his statement at bundle J, page 75:

"This question refers to procedures regarding BD submissions and is not my personal area of expertise. However, having consulted RSEs ..."

"RSE", as far as I know, stands for registered structural engineer under the Buildings Ordinance.

"... of Atkins with relevant experience, I am able to make the following observations ..."

Now, you explained to this Commission yesterday your past experience. The past 25 years you have worked in Hong Kong on many infrastructure projects; do you recall that?

A. Yes.

Q. Am I right in thinking that those infrastructure projects mostly were not governed by the Buildings Ordinance in Hong Kong?

A. A decent percentage have been highway infrastructure projects.

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Q. And they are not governed by the Buildings Ordinance?
A. Yes, highway infrastructure projects are exempt. They are not governed, yes.
Q. Without disrespect, my instructions are that you are not an authorised person in Hong Kong.
A. That is correct, I'm not an AP and I'm not --
Q. You are not a registered structural engineer in Hong Kong either?
A. That is correct.
Q. So you may not claim any expertise in dealing with design submission with the Buildings Department, getting approval or the operation of the practice notes issued to the AP and RSE; am I right?
A. Certainly, we have done work on Buildings Department projects. So we have done that -- over the past so many years, we've certainly done work on Buildings Department projects.
But yes, I'm not a RSE, so, you know, you are correct there.
Q. When you say "we" you mean your company?
A. Yes.
Q. But I'm talking about you yourself. Do you claim any expertise in this area?
A. I'm a project director of all our projects and I see everything that goes on. So, for example, we are

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working on a project at the moment which will be submitted to BD at some point and, you know, I'm involved in the review of those documents.
Q. So you said you have the expertise, right; is that your answer?
A. No, I'm just saying that I have experience of working on BD projects, but I am not a registered structural engineer.
Q. There is a registered structural engineer from Atkins, a Mr Sung, S-U-N-G, informing the Commission that as far as he was concerned, as an RSE, the diaphragm wall in question was a foundation, and therefore he made it very clear PNAP ADM-19 does not apply. Do you agree with him?
A. Well, we are getting into -- what do you call it? We are getting into areas of process.
I was asked to look at whether the structure -- whether the joint that the connection -- at the top would classify as a foundation. So, in my report, I gave my engineering response to that, and then I looked at the documents to see whether that engineering response could in any way be backed up by what was written.
I mean -- okay, carry on.
CHAIRMAN: I think that's one of the reasons, if I may step

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in, why we are not going to involve ourselves in a legal determination of what constitutes a foundation in Hong Kong, according to the various documents that relate to Hong Kong but may not relate to other jurisdictions.
So as I understand, Mr Southward, you are saying your approach was an engineer's approach to it?
A. Yes.
CHAIRMAN: Not a quasi-legal or legal approach?
A. That's why I quoted from an engineering textbook, to give some weight to my statement.
CHAIRMAN: All right. Yes. And your expertise that you've put forward today, and in terms of which you are giving evidence, is as a design consultant?
A. Yes.
CHAIRMAN: Looking at the overall safety of the structures, because that's the type of work you've been doing --
A. Yes.
CHAIRMAN: -- on complex structures over an extended period of time?
A. Yes.
CHAIRMAN: So not purely as a structural engineer? So you are not giving evidence purely as -- you are giving evidence on a broader basis of design and safety, which takes in all these various issues?

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A. Yes, but the structural engineering aspect is key to the safety.
CHAIRMAN: Okay.
A. So that's the main bit.
CHAIRMAN: And that's what you do all the time?
A. That's what I do every day, yes.
COMMISSIONER HANSFORD: Can I just ask a question here, Mr Southward, because I fear there may be a confusion. You are a structural engineer and a qualified structural engineer, it's just that you are not an RSE, a registered structural engineer?
A. I'm not a registered structural engineer in the Hong Kong BD Buildings Ordinance parlance.
CHAIRMAN: That I didn't understand. Thank you very much.
A. I'm a civil engineer.
COMMISSIONER HANSFORD: This is a very important distinction.
A. Yes. I understand.
COMMISSIONER HANSFORD: That's why I wanted to be clear about that. Thank you.
MR CHOW: Just to make sure, you are not a qualified structural engineer?
A. I'm a qualified civil engineer, so I work on civil engineering infrastructure projects. So I'm a qualified civil engineer.

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Q. So not a structural engineer?
A. I'm not a member of the Institution of Structural Engineers in the UK. So it depends how you say that. I practise civil engineering -- sorry, strike that. I practise structural engineering and I am qualified in that because I am a member of the Institution of Civil Engineers and the Hong Kong --
COMMISSIONER HANSFORD: We may be getting into quite an interesting area here -- interesting for you and I, Mr Southward, because of course civil engineering embraces structural engineering --
A. Absolutely.
COMMISSIONER HANSFORD: -- but the Institution of Structural Engineers -- and we will be hearing from Dr Glover and from Prof McQuillan later in these proceedings -- is a specialist branch that focuses on structural engineering. Am I correct?
A. Yes. So -- I mean, in my very basic -- a basic way of putting -- I don't design high-rise buildings, you know, the Nina Tower -- that kind of structure, that is structural engineering, whereas this kind of structure here that we're talking about here is civil engineering.
COMMISSIONER HANSFORD: But nevertheless, as I read from your CV, you were a director of Benaim and other reputable structural engineering companies?

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A. Indeed, yes. I mean, Tony Gee is a civil and structural and geotechnical consultant.
COMMISSIONER HANSFORD: Thank you.
MR CHOW: Mr Southward, on the issue of whether prior consultation with BD for the second change is required prior to the implementation, I have read your report, in fact the majority part of your report goes to that issue. Am I right to summarise as follows: your position is, first of all, PNAP-19 does not apply, but if it applies then your view is, first of all, the connection that is in question is part of the superstructure and therefore, under PNAP ADM-19, it is exempted because the changes is minor? Is that a fair summary of your view?
A. More or less, yes.
Q. Thank you.
Just now you mentioned -- we had an exchange on the question of whether the construction joint, the interface between the new concrete and the old concrete of the diaphragm wall has been properly prepared. Your assumption is in terms of quality, there's no problem, so it is a monolithic -- after the new concrete is cast, it is a monolithic part of the whole structure; right?
A. If the construction joint is properly prepared, then yes, that's correct.

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Q. We've had some factual evidence from Mr Jason Poon, telling the Commission that first of all the interface was not horizontal, so it's different from what people assume today, and we have some photos I would like you to look at to see whether you agree or not. Bundle B19, page 25581, please.
You see the part which is clouded in red?
A. Yes. It's not a very good photo. Maybe if you could zoom in a bit.
Q. I think that can be done, yes. Actually, Mr Jason Poon described something like an A shape. Accidentally, I found this photo, so -- obviously it is not horizontal; do you agree?
A. Yes. If that's the construction joint, then yes, it's not horizontal. It looks -- but then is this actually what it was before they -- I mean, there's no slab here; right? In fact, which side of this is the slab and which side of this is the OTE?
MR PENNICOTT: What's the date of the photo?
MR CHOW: Honestly, I can't help you, because this is a photo produced by the MTR and the annotation is by MTR as well, "Breaking out top of diaphragm wall and top couplers removed".
COMMISSIONER HANSFORD: Mr Chow, this is one of the issues with photographs, isn't it? They are snapshots in time.

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A. Yes.
COMMISSIONER HANSFORD: And we don't know if the concrete was poured immediately afterwards or if there was work done before the concrete -- we don't know.
MR CHOW: It's a fair observation.
COMMISSIONER HANSFORD: So it's quite difficult to rely on these, isn't it? I'm just asking the question: how could we rely on them, Mr Chow?
MR CHOW: Well, this photo seems to support what Mr Jason Poon said, part of his factual evidence. That's why I need to at least show it to Mr Southward, because one of his assumptions was first of all the drawing was prepared, as we saw on the drawings, which is horizontal. Then the next photo I would like Mr Southward to look at goes to the quality of the interface.
COMMISSIONER HANSFORD: Presumably, Mr Jason Poon would not have poured concrete until the joint was correctly prepared, would he? Anyway, maybe that's not a question for you, Mr Chow, is it?
MR CHOW: I can't help on that.
A. There's no reinforcement there. There's no formwork. There's nothing there. So how -- that's not ready for concreting, that photograph.
COMMISSIONER HANSFORD: No.

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A. So who knows what --
MR CHOW: I hear what you say. I show you the photo. There's some factual evidence saying that the interface was prepared in an A shape, and I found this among the photos produced by MTRC, to be fair to you --
COMMISSIONER HANSFORD: I think this shows us that at some point in time, it was an A shape.
MR CHOW: Yes, that is a possibility.
CHAIRMAN: I don't even see that, I'm afraid.
MR CHOW: Perhaps for the benefit of the Chairman, we can blow up the central part of the photo which is clouded.
CHAIRMAN: Oh, you mean the bit in the middle? Thank you.
MR CHOW: Yes.
A. You can't actually see it though. The quality is not very good.
Q. If I may ask you to look at another photo in the same bundle, 25587.
CHAIRMAN: Again, I don't wish to belabour matters, but as Prof Hansford has said it's a shot of a moment in time. How do we know that the work on that particular piece of structure was complete?
MR CHOW: Mr Chairman, the next photo that I would invite Mr Southward to look at will not have this problem.
CHAIRMAN: All right.
MR CHOW: Because the next photo shows that the

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reinforcement is almost completed, and we can see, again, in the area which is clouded, it seems to suggest that it is part of the top of the diaphragm wall. We see horizontal reinforcement had been fixed, and honestly, I'm not an expert, but my question for Mr Southward is: the bit in between the two lines of vertical blue reinforcement, would it be the concrete surface, after hacking off?
A. That looks to be the concrete, yes.
Q. Would this appear to you not to have been roughened, aggregate had not been exposed?
A. Well, it looks quite rough to me. Clearly, you can't measure from the photograph -- I don't know whether the quality of the photograph is good enough to zoom in -- is it? You can't really see anything there.
Q. Thank you. So I will move on.
CHAIRMAN: Sorry, is what's being suggested here -- and this is a new matter to me -- I'm well aware of Mr Jason Poon's observations, and there was some time spent on it, that it was sort of A-shaped, in a way, when it was cut down.
But I think what concerns me now is the broader issue, which Prof Hansford has just raised, which is that if this cutting down was not properly prepared, so that it would be structurally safe, then what on earth

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is anybody doing pouring concrete on it? I mean, that strikes me as another issue entirely.
But we will come to that.
MR CHOW: I'm afraid I am not able to assist on that.
If I may then move on. Mr Southward --
CHAIRMAN: Sorry, if I can -- I put this out as a statement, I don't make it as a question, but it seems to me that by and large, unless you've got compelling evidence otherwise, fairly obvious structural matters like that, which are being put into preparation so that they are part of a larger structure with concrete pours, one must assume regularity, unless there's good reason not to, because otherwise we are going to be looking at every last little tiny bit of this structure.
COMMISSIONER HANSFORD: I think we are also assisted by the hold point and the inspections, the pre-pour inspections, or we should be. So they are designed to ensure, as I understand it, that concrete pours are ready before the concrete is poured.
Now, I don't recall evidence to say that such hold points had been missed.
CHAIRMAN: And also, with respect, and in support of Mr Jason Poon, Mr Jason Poon, to my understanding -- and I'm open to correction -- merely said that he observed that some of the work being done resulted not in

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an entirely horizontal cut but left a sort of A shape. And he didn't say that was how it remained and that was how it was poured upon. He merely spoke about the quality of work that he saw in passing, so to speak.
Do you see the point I make? Because, of course, if he had have said, "And that was what I was faced with when I had to pour the concrete", then, as a professional man, no doubt, running his own operation and with responsibility to ensure that it operated properly, he would have been obliged, because he was now the one responsible, to say, "This is not a properly prepared surface", and I don't recall him ever saying anything like that.
MR CHOW: Not that I'm aware of either, sir.
CHAIRMAN: No.
MR CHOW: The reason why I need to show or bring to the attention of the Commission these photos is because other experts make the point that it is important to ensure that the interface is properly prepared, aggregate are exposed, to ensure that after the casting it will become a monolithic part of the whole structure.
And when I noticed this photo, given the duty of the Commission, I am duty-bound to at least bring to the attention of the Commission.
CHAIRMAN: No, it's not a criticism. This type of debate or

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interchange between the counsel and the Commission is quite proper and assists. But what we are saying, I think, is that Mr Jason Poon did not say, "I poured concrete in accordance with my contract on top of an ill-prepared surface." He did not say that. He spoke about -- to use French, which I'm not supposed to do, I suppose, in courts today -- he spoke about what he saw en passant. That's all he did.

I think there's been no other suggestion that this was wrong. I'm happy for a hypothetical question to be put, that "What would be the case if it wasn't prepared?", but I'm not happy to now have another factual issue, which nobody has touched upon in several weeks of this Inquiry, now falling for determination, because I think so far everybody accepts that whatever the work may have been in passing, at the end of the day nobody suggests that it wasn't properly prepared.

COMMISSIONER HANSFORD: But it would be interesting to know what would be the case if it were not properly prepared, so we might proceed on that basis, if it suits you.

MR CHOW: Yes. Thank you.

Mr Southward, may I ask, if the interface between the new and old concrete had not been properly prepared, would it have any effect on your view?

A. Can you define what you mean by "properly prepared"?

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Q. The aggregate was not properly exposed, surface was not clean, for example.

A. There is a specification requirement for preparing a construction joint, which means removing the latent, which is the stuff that floats to the surface of a construction joint, and then ensuring that the amplitude of the exposed stones above the grout part of the concrete is at least whatever the number is. I can't remember. 6 millimetres, maybe? I can't remember.

So there is that specification, the requirement for preparing a construction joint.

But this photograph does raise one point. Yes, we don't know what it is, but another part that you mentioned about construction joints is it being horizontal, and really whether it's horizontal or not, that doesn't really matter.

If I could draw, I could explain -- can I draw?

Q. Yes. That would be of assistance to the Commission.

A. So a concrete wall (drawing red vertical lines) and rebar (drawing blue vertical lines), and if the construction joint had been prepared in an A shape, then, you know, you would get -- you would see that (drawing a squiggly red line); right?

COMMISSIONER HANSFORD: That's right.

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A. The question about properly preparing a construction joint -- this concrete was originally up here (drawing red line at the top), way above the top of the final level, and then it was broken down.

So in the breaking down, you use a big machine to do the top bit and then you go into small, hand-held breakers, and in doing that, that is going to guarantee that the finish of the concrete is going to be properly prepared, because you are basically hammering out the bits of the concrete. So you are going to get a rough finish.

So I don't have any doubt, because they were up here and they went down here (indicating), I don't have any doubt that the surface would have been properly prepared.

The question about the profile -- we talked about dowel action earlier, but if we got this slab (drawing a horizontal red line), and we got Prof Au's free body slice, which was this slice here (drawing a red box), and he doesn't want that slice to move sideways -- well, now we've got a shear key there (indicating), inside, that is actually stopping the body from moving regardless of the reinforcement.

So, okay, we don't know whether it was done that way, but if it had been done that way, that would

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actually be better than it being a flat surface.

COMMISSIONER HANSFORD: Right. But it would be the case that it would complicate the analysis of the free slice?

A. It wouldn't make any difference to the analysis --

COMMISSIONER HANSFORD: Would it not?

A. -- really, because from the perspective of design, once the construction joint is prepared properly and the concrete is poured, it becomes a solid, monolithic piece of concrete.

COMMISSIONER HANSFORD: Sorry, I meant -- what's it called -- the free position analysis that Prof Au was referring to, the free block.

A. The free body?

COMMISSIONER HANSFORD: The free body.

A. You no longer have a free body that shape (drawing a blue square), you have a free body that shape (drawing a square with an A shape at the bottom).

COMMISSIONER HANSFORD: That's why I was wondering whether it would complicate the analysis.

A. There would be a resisting force here (drawing blue arrows), so that when you are pushing this way you've got to shear off the A, as well as the reinforcement.

COMMISSIONER HANSFORD: So it would improve the situation?

A. So it would improve the situation.

COMMISSIONER HANSFORD: I'm sure nobody is advocating

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A-shaped construction joints.
A. I don't know. I don't know.
MR CHOW: Mr Southward, I would like to move on to the next topic. Earlier, you mentioned about the textbook that you referred to, the foundation analysis. Do you recall that, Foundation Analysis and Design?
A. Yes.
Q. In support of your view that the connection in question should be treated as part of the superstructure. Do you recall that?
A. Yes.
Q. But you have not -- if I am correct, you have not provided copies of that textbook, have you?
A. No, I didn't realise I was supposed to, I'm sorry. They are expensive! Ignore me.
Q. I have managed to get somebody providing support to me to download the relevant part of that textbook, apparently free of charge, from the internet. If I may perhaps distribute. (Handed).
COMMISSIONER HANSFORD: Which textbook is this?
MR CHOW: This is Foundation Analysis and Design referred to by Mr Southward in paragraph --
A. Joseph Bowles?
Q. -- 14.2, page 40 of Mr Southward's report.
COMMISSIONER HANSFORD: Thank you.

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MR CHOW: You relied on this textbook in support of your argument that the connection we are looking at should be treated as superstructure.
If I may refer you to the relevant part. The part that you have quoted actually can be found right in the first paragraph of the book, chapter 1, the first paragraph of chapter 1 of the book, where it says:
"All engineered construction resting on the earth must be carried by some kind of interfacing element called a foundation."
And under footnote 1 it makes a point that:
"This is also sometimes called the substructure."
So according to this book, "foundation"/"structure" are interchangeable.
Then is the statement that you relied on and quoted in your report:
"The foundation is the part of an engineered system that transmits to, and into, the underlying soil or rock the loads supported by the foundation and its self-weight."
And it goes on to say:
"The resulting soil stresses -- except at the ground surface -- are in addition to those presently existing in the earth mass from its self-weight and geological history.

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The term superstructure is commonly used to describe the engineered part of the system bringing load to the foundation, or substructure."
So these are the two sentences that you quote in your report to support your view. However, the book does not stop here. If you turn over the page to page 3, basically, in section 1-3, it is where this book tells us how to classify and what kind of structures should be considered as foundation. Section 1-3:
"Foundations may be classified based on where the load is carried by the ground, producing:
Shallow foundations -- termed bases, footings, spread footings, or mats. The depth is generally D/B less than 1 ..."
Meaning the depth against the width of the foundation. If it is less than or close to 1, it is considered to be a shallow foundation. Then:
"Deep foundations -- piles, drilled piers, or drilled caissons. Lp/B is greater or equal to 4 ..."
Then the next paragraph:
"Figure 1-1 illustrates general cases of the three basic foundation types considered in this text and provides some definition commonly used in this type of work. Because all the definitions and symbols shown will be used throughout the text, the reader should give

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this figure careful study."
Figure 1-1 is on the next page. You see on the next page we have three types of structures, all considered to be foundation: (a) is the spread foundation that we have just looked at, (b) is the pile foundation, and (c) is the retaining structure.
Now, do you agree with me that the part of the diaphragm wall between the EWL slab and NSL slab is a retaining structure?
A. It is a retaining structure, yes.
Q. If I may just complete the relevant part that I intended to show to you. Page 5, the third paragraph from the top, starting with "Any structure"; do you see that?
A. Yes, I see it.
Q. "Any structure used to retain soil or other material (see figure 1-1(c) [the one we have just looked at]) in a geometric shape other than that naturally occurring under the influence of gravity is a retaining structure. Retaining structures may be constructed of a large number of materials including geotextiles, wood and metal sheeting, plain or reinforced concrete, reinforced earth, precast concrete elements, closely spaced pilings ..."
Do you agree with me that the diaphragm wall that we have with interlocking can be considered -- if we want

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to refer to this paragraph, actually it's akin to a closely spaced piling to resist -- to retain the soil on one side?
A. Well, closely spaced piling refers to things like contiguous bored pile walls, which is not the diaphragm wall.
Q. Of course, but what I'm saying is how it works, the diaphragm wall that we use in this project is akin to if we want to somehow relate to the closely spaced piling or any one type of structure here, the closely spaced piling would be the appropriate reference; right?
A. Well, I mean, you are just looking at the words. The words say "closely spaced piling", they don't say "diaphragm wall". And on the issue of retaining walls and diaphragm walls -- retaining walls and foundations, in Hong Kong they are two very distinct elements.
There is a code of practice for design of foundations, and there is also a separate document which is a code of practice for design of retaining walls. So they are separate.
Q. All right. Looking at -- we have now looked at the relevant part of the textbook that you relied on. Do you agree with me that the connection we are interested in between the EWL slab and the diaphragm wall should not be treated, according to the textbook, as part of

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the superstructure?
A. Well, I think it is part of the superstructure because it is -- looking at the first page, a superstructure "is commonly used to describe the engineered part of the system bringing load to the foundation". So the station box structure, that is an engineered structural system that is supported on diaphragm walls below.
But I say this just from an engineering perspective. Please understand me.
CHAIRMAN: All right. Could I ask you this then, because I've already made clear that we're not going to come to a decision legally whether in Hong Kong these constituted whatever they constituted, and if we were going to I would demand a good deal of authority, legal authority, before I was going to make that decision. But perhaps more important is the issue of -- if you're working towards a common goal, namely the building of a structure, and you know that that process involves oversight by a building department, are there occasions when, even though you may be of one view, you feel nevertheless you should consult with that oversight body, namely a building department?
I mean, do you do that in your daily work? Do you say, "Well, I don't think we need to, but I think we should"?

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A. No. I mean, it doesn't work like that. You can't just ring up and say, "Can you help me here?" You know, you've got to make formal submissions.
CHAIRMAN: Okay. Good.
A. You do the work, you read the documents first to make sure you're fulfilling the criteria. You do the work, you prepare the submissions, and then they are submitted, and then there's a review period, which takes a while. So you don't have -- as far as I know, there's no facility for, "Can I have some advice here, please" on this.
CHAIRMAN: I'm not talking about a helpline, as such -- I don't mean that facetiously -- but I'm wondering if you can write in, formally, to the Buildings Department and say, "We intend to do this, we see it not as a design change, but before proceeding can you give us the okay", or will you then get a request to formalise it?
A. I don't know because I've not been in that situation, sir.
CHAIRMAN: All right. So for you, if ever there's going to be a change, because of the formalities of the process, you and those who work with you will make a decision as to what it is, whether you need to consult with the Buildings Department or not, and then you will proceed,

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if you feel you should consult, with a formal application?
A. Yes, but this is to do with a change on site.
CHAIRMAN: Yes.
A. In this instance, it's a change on site. I'm working in a design office, so my day-to-day working -- in the design office, we are not really in the same situation as the change on site.
CHAIRMAN: Okay. I'm with you. Okay. Thank you.
MR CHOW: Mr Southward, there is evidence from Atkins -- well, actually, you recall you have looked at the design report prepared by Atkins, 4B3, TWD-4B3, the temporary --
A. I've seen so many reports. I haven't memorised their numbers.
Q. Perhaps I will cut it short then. In one of those reports prepared by Atkins, Atkins put down clearly that the diaphragm wall was designed as a foundation system; right?
A. I really can't remember --
Q. Perhaps I can take you to that particular part. B12/9012.
CHAIRMAN: I'm going to let you proceed here, but I think I've thrown enough red flags up now to distract a herd of bulls.

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MR CHOW: I'm going to move on pretty quickly. Sorry. I just want to ask you one last question on this subject. If you look at the bottom of the page --
A. Can I just see the front page of this report, just so I can get it in context?
Q. Yes. The front page --
COMMISSIONER HANSFORD: I think we are finding you a hard copy.
MR CHOW: Yes. 8984.
A. I think I've got that somewhere, yes.
Q. If I can refer you to page 9012. Under paragraph 3.2.2.1, Atkins confirm that:
"Diaphragm walls and barrettes are employed as the foundation system."
But I only have one question for you: would that make you change your view as to whether that part of the diaphragm wall should be considered as superstructure?
A. Well, I think I would say that statement written is not true.
Q. All right.
A. Because it says -- the second sentence says:
"Both will have a nominal embedment (300 millimetres) into acceptable rock."
Now, as I understand it, the diaphragm walls are constructed on a hit-and-miss basis, so every third

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panel goes into the rock but the other two panels are founded at a level much higher, so therefore that statement is not actually right.
Q. All right. I will move on to the next subject, the CASTCO -- the testing done by BOSA.
In your report you said because of the test result, "This therefore becomes the acceptable standard for a pass or fail of thread engagement."
Am I right in understanding that what you actually intended to say is that these new -- the 60 per cent partially engaged thread length ought to become a new acceptable standard? Is that what you really intended to say?
COMMISSIONER HANSFORD: Which paragraph is this?
MR CHOW: That is section 15.5.
COMMISSIONER HANSFORD: 15.5. Thank you.
MR CHOW: Page 49.
MR PENNICOTT: It starts at 47.
MR CHOW: The fourth paragraph, starting with "At 60 per cent":
"At 60 per cent thread engagement the test showed that the failure load was 886 kilonewtons and the failure occurred in the parent bar. This therefore becomes the acceptable standard for a pass or fail of thread engagement. 60 per cent thread engagement of the

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nominal threaded length of 44 millimetres is 26.4mm."
A. Sorry, I'm just waiting for the words to come up, just so -- it would be easier for me to read them.
Q. Page 49, the fourth paragraph from the top.
A. Okay. I could have written, "In my opinion, this therefore could become the acceptable standard for a pass and fail", but, I mean, the whole report is prefaced on the basis that it's my opinion.
Q. Understood. Yes. I just wanted to clarify, because I thought that is what you actually mean. Right. Thank you.
In section 15.6, here you refer to the fact that the yield strength of the reinforcement used on site was higher than the assumed 460 megapascals, and you therefore suggest that we may perhaps have a further 8 per cent reserve in the capacity of the section. Do you recall that?
A. Yes.
Q. In the various steel reinforcement testing reports, we notice that there are some reports that show actually the reinforcing bars used did not have 500MPa. I just want you to take a look to see whether you have the same interpretation.
Bundle B5, TS35254, please.
Yes. First of all, on top of the page, right-hand

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side, it's stated, the fourth item, you see that on the right-hand side, "Grade of steel" is indicated to be 460?
A. That's what's written there, yes.
Q. If we move down to the lower part of the table, where it sets out all the test results, you see there is an entry, an item called "Yield stress"; right?
A. Yes, I can see that.
Q. And three samples have been tested. Two of them show a yield stress of less than 500, and the mean yield stress is 499, close to 500 --
A. Yes.
Q. -- but not 500.
If we now move on to another test report --
A. Before we do, while we've got this one here --
Q. Yes.
A. -- at the top of the page it says "Results of tensile tests", "Bar identification marking", "Mass per metre run", "Effective sectional area", and it goes 112.4, 109.9, 110.1. That's a T12 bar, so that's very different from the T40 bars. This is a test for a T12 bar which is not the T40 bar, and up in the slab they used T40s and T50s.
So do you have the same for a T50 bar?
Q. I don't know. We just noticed there are some test

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reports, so that's why I wanted to show it to you, to see whether you have any further input on that.

Another test report, at page TS35375 -- we may have the same problem here because honestly I haven't noticed this but I just want to make sure -- these are again --

A. These are T16 bars.

Q. So that would not affect your opinion; right? So we can still safely allow for another --

A. Not on the basis of this.

Q. Okay.

A. Clearly the person to ask is the stockist and the manufacturer.

But, I mean, I asked Leighton -- it was a question that I asked them -- "Can you tell me what grade of steel?", and they responded to me, "We used grade 500." Grade 500 was used. But, I mean, I don't have any certificates or evidence of that. I just took that at their words. So --

COMMISSIONER HANSFORD: I'm sorry, I don't wish to interrupt.

A. No, it's okay, please.

COMMISSIONER HANSFORD: This is an interesting area for me and this has come up earlier in these proceedings, that we don't know whether we are dealing with 460 or 500, and my understanding is there was a point in time when

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the market changed from 460 to 500. But what I had not appreciated, and perhaps I'm still not sure, is as to whether it changed for all diameters at the same time or whether T12s and T16 were still at one grade and T40s T50s at another. Do you have any knowledge of that?

A. I don't, no.

COMMISSIONER HANSFORD: It will remain as a puzzle.

A. I must clarify, I'm not relying on that 8 per cent -- the numbers I said yesterday, about 40 per cent reserve and stuff, that 8 per cent isn't there. That's just sorted added bumpf, if it turns out to be the case that it is grade 500.

COMMISSIONER HANSFORD: So the point you have made about redundant capacity, I'm not going to get tied up into definitions here --

A. Spare capacity.

COMMISSIONER HANSFORD: -- spare capacity, let me use that term, spare capacity -- is on the assumption of 460?

A. 460, and just from a design perspective.

COMMISSIONER HANSFORD: From a design perspective. Thank you. That's helpful.

MR CHOW: Sir, I only have one more topic to cover but I note the time. Perhaps it's a convenient moment that we have --

CHAIRMAN: Good. Thank you.

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MR SHIEH: Before we rise, perhaps some references for the Commission to consider in its spare time. It's as good as any for me to raise it.

CHAIRMAN: Yes.

MR SHIEH: Just now, there was a reference to earlier references in the evidence to A shape or tapered. Can I just give the Commission the evidential reference to when it was raised previously in the course of evidence?

CHAIRMAN: Thank you.

MR SHIEH: The first time it was raised, not surprisingly not in the witness statement, is in Mr Poon's testimony on Day 7, page 142.

MR PENNICOTT: To 144.

MR SHIEH: Mr Pennicott has found it.

MR PENNICOTT: I just checked.

MR SHIEH: Page 142, line 19 to page 144, all the way to the end of 144.

MR PENNICOTT: Yes.

MR SHIEH: Then it was picked up by the government in cross-examination: Day 11, page 94, line 15, all the way down to page 102, line 25. Those are the areas I could locate --

CHAIRMAN: Thank you.

MR SHIEH: -- where the issue about A shape or tapered diaphragm wall was mentioned. Maybe Mr Pennicott has

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located --

MR PENNICOTT: I have one further one. On Day 24, page 39, when Mr Chow was cross-examining Mr Buckland of Leighton regarding the A shape, evidence given by Mr Poon.

MR CHOW: Thank you.

CHAIRMAN: Thank you very much. That assists us. Thank you.

Good. 15 minutes. Thank you.

(11.40 am)

(A short adjournment)

(12.02 pm)

CHAIRMAN: Yes.

MR CHOW: Mr Southward, there is only one last matter I would like you to help me with, and for this I would need to borrow the bending moment diagram prepared by Prof McQuillan, if I may. Page 39 of tab 3, please. Do you see that?

The way I understand it is -- here, Prof McQuillan drew the bending moment showing the variation of bending moment along the EWL slab; do you see that?

A. Yes, it looks like it.

Q. Then on the two sides we see the blue line, the curved line, also shows the bending moment inside but along the diaphragm wall on each side, under the usual loading that we usually see acting on that structure.

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In terms of the general shape of this variation of bending moment, is that what you expected as well?
A. Yes. For the top slab -- I mean, in the D-wall, it very much depends on the moments that are built up in the D-wall during construction. So I can't recall exactly. But there are reports that have all the D-wall bending moment diagrams in them quite clearly. But this looks about right, yes.
Q. For the benefit of a layperson, what we see the blue line here represents is -- for the blue line above the EWL slab, it shows that there is a hogging bending moment; is that right?
A. Correct, yes.
Q. The blue line -- for the region where the blue line is under the EWL slab, it represents that the moment there is a sagging moment, in other words in another direction?
A. Correct.
Q. What I am interested in is the location where we have the bending moment equal to zero, that is the location where bending moment inside the EWL slab starts to change direction.
I myself just tried to scale it off. The location is about one-fifth of the span of the EWL slab. Does it appear to you to be roughly proper, in order?

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A. I couldn't say. You're talking about the point of contraflexure.
Q. Yes.
A. And this is a schematic diagram. I'm sure it's not plotted based on real values. We'd have to go and look in the Atkins report to see exactly where the point of contraflexure was. But perhaps in a typical beam, one-fifth in or whatever might be a point of contraflexure.
Q. Of course I know the exact location would depend on the loading, depend on the structure and the size of member.
A. Yes.
Q. I fully accept that. But as a general phenomenon, the location, although it varies, would be within a certain range; would you accept?
A. It can vary. The point of contraflexure, it can vary widely depending on the loading applied to the frame. It really can. And also how the structure was built.
So the manner in which the structure was put together, because the manner in which it was put together affects the shape of the bending moment diagram.
COMMISSIONER HANSFORD: When you say "manner put together", you're referring to -- in this instance, we have a top-down method; is that the sort of thing you're

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referring to?
A. Yes.
COMMISSIONER HANSFORD: So we've got a method where the top slab is constructed and then excavation takes place underneath it?
A. Yes.
COMMISSIONER HANSFORD: In fact Prof McQuillan shows that sequence and I'm sure we will come to that when we ultimately get to him, probably tomorrow.
A. It may be the manner in which it's put together is most easily explained by a bridge, a simply supported span bridge. When that bridge is built, it's a simply supported span, but sometimes bridges are then made continuous with the next-door span.
COMMISSIONER HANSFORD: Yes.
A. In that case, the bending moment diagram is very different compared to if you built two spans together at the same time.
COMMISSIONER HANSFORD: Yes. Thank you. That's helpful.
MR CHOW: The matter that I would like you to help me with is to understand the answer that we received from COWI last night. I'm not sure you've had a chance to read it.
A. I've not seen it, no.
Q. It has been inserted into the bundle. I believe it's

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tab 4.1 or 4.2.
MR PENNICOTT: 4.5.
MR CHOW: 4.5, sorry. Thank you.
This is the answer that we received last night. I would like you to look at question 2. Perhaps if you would like to take some time to read question 2 and the answer provided by COWI.
A. Okay. Move up.
Q. Thank you.
A. Sorry, "move down" I suppose.
Can you just move up -- can I read the question again, please?
Okay. I've think I've understood that.
Q. Mr Southward, perhaps I will give you some background information first. The reason why we asked question 2 is because it is agreed between all the experts that at the connection between the EWL slab and the diaphragm wall actually experienced hogging moment, and that's the reason why the experts agree that the bottom steel is subject to compression.
A. Yes.
Q. This is also part of your view. So we would expect hogging moment to appear along the top of the east diaphragm wall. But when we look at the details of COWI's calculation, there is one loading case which the

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result shows all along the east diaphragm wall, the top of the east diaphragm wall, there is a sagging moment, and that's why it appears to the government as something that needs to be explained, and that's why we raised the question.

Now, we received the answer from COWI last night. The way I understand it is what COWI tells us is, yes, at the centre line of the diaphragm wall, the moment was a hogging moment, but as soon as we move outside, up to the interface, we are talking about 600 millimetres of distance away from the centre line, theoretical support. The hogging moment becomes sagging moment.

So we are talking about the change of bending moment within a very short distance.

The reason why I need to borrow Prof McQuillan's bending moment diagram is to try to understand whether it is reasonable. Now, according to Prof McQuillan's bending moment diagram, the point of zero moment should -- I take your point that it may vary -- but generally would be at 20 per cent or 15 per cent away -- 20 per cent or 15 per cent of the span away from the support.

But in this particular case, according to COWI's analysis, we are talking about 600 millimetres away from the support, for a span of 25 metres. In other words,

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the point where the moment starts to change, it's even closer than 600mm.

Now, I am not an expert but I am instructed by those who know this matter that there must be something wrong with the analysis, and I want to hear what is your reaction to that.

A. Okay. So you said a loading case, so that would mean -- that would indicate that it's a loading case.

Q. Yes.

A. You have loading cases and then you go to load combinations, and the load combination is the one that we designed for.

So I don't know which loading case it is, but if you put load onto a structure in isolation from any other load, then you might have a case that the sagging moment goes all the way to the end of -- all the way to the walls. Like what? What example would that be? Maybe the live load or -- one discrete case might have a bending moment diagram that goes all the way to the end, but these diaphragm walls are -- the analysis, so far as I've understood everyone's done, everyone's done a Plaxis analysis, which is a geotechnical software, and that gives you the bending moments in the diaphragm wall. And the bending moment at the top of the diaphragm wall is a very large hogging moment, which is

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much, much larger than any of the other loads that are applied to the slab itself. So that hogging moment dominates.

Now, onto that hogging moment, you have to add the bending moment diagrams from all the other different load case situations. So maybe one of those load case situations creates a sagging moment. Maybe temperature or -- I don't know, because I haven't studied it in depth. But I can see a scenario in which case a single loading case exhibits what you said, but that's not the same as the final design moment.

COMMISSIONER HANSFORD: So are you saying that with one particular loading case there may be a sagging moment, but that's counteracted by the hogging moments from other load cases?

A. Yes. Maybe -- can I draw?

COMMISSIONER HANSFORD: Yes, please. That would be quite useful.

A. If you don't mind. A new page.

(Drawing with a black marker) The Plaxis run models the slab at the two joints, the two slabs, and there are some struts; I think there's a diagonal strut in there as well. So it models the whole building --

COMMISSIONER HANSFORD: There's a diagonal strut during the temporary work?

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A. During construction, yes. I think there's a strut.

COMMISSIONER HANSFORD: Again, I think Prof McQuillan shows that in his sort of sequence of construction which we will come to tomorrow.

A. So the Plaxis run models the whole life of the structure during the construction stage and it ends up with a bending moment diagram, and I have to say, where it goes down here (indicating), I'm not sure. Maybe it does that (drawing a curving line), that kind of shape.

But the big thing is that up at the top of the wall, there's a significant hogging moment, which means that in the slab there's a significant hogging moment like that (drawing with a black marker). So that's very large.

And maybe the order of magnitude of that bending moment from the Plaxis run is maybe 70 per cent, I'm guessing, 80 per cent, that kind of number, maybe. But it's large.

Then you might have another loading case that you have to consider, and because of the way the load is, maybe a particular train over here (indicating) causes that kind of shape (drawing with a red marker) with a very small transfer of moment around the corner.

But for design, we have to add these two together. So you add that to that (indicating), multiplied by

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various factors and things. But in this point here, it's that, and actually that's a minus, because it's a different side.
COMMISSIONER HANSFORD: That's what I meant by one countering another; am I correct?
A. Yes.
I don't know whether that is the case, but that would be an explanation for that case.
MR CHOW: My last question, probably not a good question, in that particular load case, where the bending moment generated within the diaphragm wall manifests such a sharp or quick change in bending moment within a very short distance, does this mean that the mid-span moment would be very large, in such circumstances?
A. Yes. In that case, it means the mid-span moment might be larger, but it depends on the magnitude of the load applied in the beginning.
Q. Of course, yes. Would you recommend, in those circumstances, someone has to check whether the mid-span is strong enough to resist that sort of a large bending moment?
A. Sorry, can you say --
Q. The load case that we have looked at resulted in a very sharp change in bending moment, close to the support.
A. Yes.

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Q. And you agree with me, in such circumstances, the mid-span moment tends to be very large as well?
A. No.
Q. Not necessarily?
A. No, because the gradient changes, it's a very sharp peak, and then as you go further away from the wall, the gradient becomes less and less and less and it flattens out. So just because that's very steep (indicating) doesn't mean that this (indicating) is going to be very big, because it doesn't continue at this angle all the way down. It sort of comes here (indicating) and then the gradient gets less and less and less and then the gradient becomes flat (indicating the whiteboard).
Do you understand?
Q. I understand what you say, yes. I thought the bending moment diagram is a kind of parabola.
A. Yes, a parabola is one that is very steep at its steepest bit and then as you go away it becomes more and more flat (demonstrating with hands).
MR CHOW: Thank you very much. I have no more questions for you. Thank you.
Cross-examination by MR SO
MR SO: There are some questions from China Technology.
Mr Southward, I am Simon So; I represent China Technology.

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I just heard you had a discussion with Mr Chow on the photograph. I wish to invite you to assist me, actually, because I don't really know anything about engineering. Can I trouble you to take a look at the photograph that Mr Chow just showed you: B19/B25587.
Just so you can help me, if I do not misunderstand this photograph, the bars that are painted in blue colour, the area which is clouded in the red lines, are actually the diaphragm wall; correct?
A. Yes, I believe so. It looks like it, yes.
Q. Can the photograph be blown up a bit to the right of the diaphragm wall, those bars placed horizontally. If it could be even larger, please. Yes, thank you.
Do we not see some lapping of the bars there?
A. Yes, the bars that go across the top of the diaphragm wall, in this area here, appear to be -- it seems to be a local area where there is some lapping, yes.
Q. But insofar as I understand, as you just explained to this Commission in your figure 9 of your expert report, did you not say that the new design is one of through-bars which there should be no lapping?
A. Yes. I thought I explained: through-bars across the top of the diaphragm wall. I can't control this, can I, but if we look at the bars --
COMMISSIONER HANSFORD: We can get a little hand on there

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for you, actually. We have that technology, I believe. Is the hand coming? There we are.
A. If you move the hand between one set of blue bars and the other bars on the other side, along the line -- so keep moving that hand backwards and forwards -- so that is a through-bar and that's going through the diaphragm wall and it goes out each side.
COMMISSIONER HANSFORD: Right. So are you saying the lapping takes place outside the diaphragm wall?
A. So if we then move the hand to the right, you will see that one bar turns into two side-by-side bars. So, in that area, there is a lap between one bar and the other bar.
But that does appear to be only in this local area. If you look more up the top of the photograph, there don't appear to be any laps. So maybe there was some kind of opening or some kind of feature in the slab that necessitated the use of lapped bars in this particular area. Maybe. I don't know.
MR SO: Thank you. Just to move to a completely different topic. Just to cut a long story short, if I can put it bluntly: the test that you are trying now to suggest, or the standard, rather, you are trying now to suggest, is that as long as there is engagement of 60 per cent of the threads into the coupler, that would be adequate?

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A. What I'm saying is that some testing has been done, and that testing demonstrates that the strength of the bar coupler assembly is strong enough to meet the criteria of strength for the performance of the station structure.

So that is a real -- it's a real thing. It's something that we've actually seen. We've seen a test and it's been tested and we know it's strong enough. So that's what I mean. If we have 60 per cent engagement, that's what happens, so we know the structure is then safe.

Q. And when you say "some tests", I understand that you are referring to the CASTCO test that you have referred to in page 48 of your expert report; correct?

A. Correct.

Q. Just so I don't misunderstand, that is also the only test, one and only one test, that you are now basing this hypothesis on; correct?

A. I believe there were five or six tests, but yes. The results of those tests.

Q. All right. Just to make myself clear, when I say "one test", I mean just the static tension test; correct? That is five different tests based on the static tension test, one type of test?

A. Yes.

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Q. Right. I don't need to trouble you to go to the QSP, but you certainly will understand that under the QSP, they stipulate more tests, not just one type of test; correct?

A. Correct.

Q. Those are the permanent elongation test and cyclic tension tests; correct?

A. Correct.

Q. I wish to invite you to go to a discussion that you had with my learned friend Mr Pennicott yesterday. It is in transcript Day 42, page 131, line 24.

There, when you were answering queries from Mr Pennicott, you were trying to say that:

"The testing of couplers to compliance to BD rules is a kind of -- is a different thing. It's testing them with respect to the specification requirements, so that those couplers can be used in any situation anywhere."

Now, when you are talking about the testing of couplers to compliance with the BD rules, you are mentioning those permanent elongation tests and cyclic tension tests, were you?

A. Yes.

Q. Insofar as -- so that I don't misunderstand your evidence, you are saying that the static tension test goes to the structural integrity, and those two tests do

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not go to structural integrity and just go to compliance with specification; is that your evidence?

A. No. All those tests are all part of demonstrating that the coupler is satisfactory for use in any situation, in any civil engineering application.

Q. All right. Just to move on slightly -- it is at page 132 -- then Prof Hansford asked you, in line 20:

"Sorry, Mr Southward -- so are you saying you don't believe elongation to be relevant to this project?"

Your answer -- to be fair to you, you say:

"... no. If you are looking at it from the point of view that I was, 'Is the structure safe?', then that's where I came from."

That is the part which troubles me, Mr Southward. So are you saying that the permanent elongation test and the cyclic tension test has no contribution to structural safety?

A. Those tests are all part of a process of ensuring the quality of the product so that product can be used anywhere.

Q. And the quality of the product certainly goes to structural safety; correct?

A. The quality of -- yes. I mean, structural safety is -- when you have a functioning coupler, you then have structural safety, yes.

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Q. Good. So in order to have a full picture of whether the coupler assembly is safe, you need all the three tests; correct?

A. Well, some tests have been done and they have --

Q. Don't tell me some tests have been done. There is just one test done. Just the static tension test was done, is it not?

A. Yes, and that is what is happening in real life out there. The station structure is there in a static arrangement, with a large load in the bars, now, as we speak. So that coupler assembly is under a static load.

I think I also said that the future loading on this coupler assembly is due to the trains, as the trains move over the platform, and the stress in those bars is quite small.

So when you do the cyclic tension tests and you do the elongation tests, you are pulling the bar up to 0.6fy, which is a large load; 0.6 times 460 is, off the top of my head, 300.

Q. I don't think we need to go to the rocket science of those tests.

A. Whereas the actual stress in the rebar due to the loading is maybe 15MPa, somewhere around that, of that low double-digit figure.

So really, it we look at the coupler, it's under

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a static load. So we've got to test it statically to make sure it can resist the applied static load, and that's what those tests show.
Q. Let me try it another way. The station is now not yet in use; correct?
A. Correct.
Q. Your evidence, insofar as I understand, now the station is static, the permanent elongation test and the cyclic tension test, at this stage, at this moment, does not concern about structural safety; correct?
A. I don't think I'm saying that, no --
Q. So what's your evidence?
A. What's my evidence? What do you mean?
Q. Let me put it another way. In the current state, which is static, is it your evidence that the permanent elongation test and the cyclic tension test can shed no light whatsoever to structural safety of the station?
A. I think all testing gives confidence in performance of things. That's why people do tests. So I'm not saying that you shouldn't do testing. Testing is good.
When I'm looking at the station, in this particular instance, with it being built, I know it's not open but apparently trains have run across the slab, so it's experienced its design loading. There has been no sign of reported distress. All the calculations indicate

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that there is a massive reserve of strength there, so we've got to look at what is the most relevant test that we can do that proves that the bar/coupler assembly will not break. So what is that test? That test is a static load tension test, to replicate the condition that the bar/coupler assembly is in at this moment.
Q. In other words you are saying that if the station passed the static tension test, then because of this nature the permanent elongation test and cyclic tension test would be subordinate, in a sense, to the static tension test; is that your evidence?
A. I'm not quite sure what you mean by is that my evidence, but what I'm saying -- what concerns me, as a structural engineer, in this instance, is the ability of the bar to not break, because I know that the loadings placed on this bar are of a static nature and not a cyclic nature.
COMMISSIONER HANSFORD: Sorry, when you say the "loadings placed on this bar", do you mean the loadings placed on this bar now, or do you mean the loadings placed on this bar now and in the future?
A. Now and in the future, yes, because the loading placed on this bar is pretty much -- is close to the maximum load that this bar will experience, because it's in its final state and it's buried, it's encapsulated in the ground, and what happens -- what comes onto it now are

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just trains. And yes, trains are big and heavy but they're nothing compared to the weight of the slab, the 3 metre thick slab, the span of the wall between the slabs. So everything is on a massive scale. So the loading on the bars is much larger now than any future train loading. Does that make sense?
COMMISSIONER HANSFORD: It does. To me it does. Thank you.
MR SO: So you are saying that as long as it passes the static tension test at this point in time --
A. Please don't get me wrong. I'm not saying: don't do the cyclic test. I'm not saying that. I'm saying from my perspective, and what I was engaged at, was to look at the safety aspects, and I'm satisfied if the static tension test can be met -- and that wouldn't be the case for every structure. I mean, I said yesterday about a coupler at the base of the Nina Tower. I mean, there -- the loading situation there is completely different, and there that coupler would experience large reversals of force, and so other tests may be relevant, or will be relevant, for that coupler. But that's a different situation to where we are now.
Q. All right. Can I bring you to the letter which BOSA writes to the Buildings Department. That is in bundle H25, page H45858.
COMMISSIONER HANSFORD: Sorry, Mr So, the date of that

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letter?
MR SO: 7 January 2019.
CHAIRMAN: You heard what I said about that?
MR SO: Yes, I heard that. I took that into account. I think it would be of benefit if this expert can give evidence or give his expert opinion as to what he sees in terms of the response given by BOSA.
CHAIRMAN: That's fine, as long as you are aware of my concern as to weight. When you've got a letter written in the middle of a controversy where you may well be held to account, that letter is going to look to absolutes and on a defensive basis.
MR SO: Of course.
A. Can I point out, I'm not -- I think someone had this letter on the screen the other day, but I've not actually seen this letter. It was written -- dated after the submission of my report.
Q. Indeed, we do appreciate that.
A. I've not read or studied it or --
Q. Do you want to have a chance to read it now?
A. It depends on what you are going to ask me.
Q. Sure. Of course. Perhaps I will draw you to specific paragraphs which I wish you may give us some insight upon. It is in page H45859. I want to draw your attention to the second paragraph. Ill just read it

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into the record. There it writes:

"Regarding your question on how a partially engaged coupler would perform in permanent elongation test, static compression and tension tests and cyclic tension-and-compression tests, it is our opinion as explained in paragraph 4 above, that it is unlikely that such couplers, without being spliced butt-to-butt and are therefore loose, will survive permanent elongation, and cyclic tension-and-compression tests."

Mr Southward, correct me if I am wrong, my understanding is insofar as you are aware, there were no static compression and tension -- permanent elongation test and cyclic tension-and-compression test being performed?

A. I've not been made aware of those.

Q. Are you able to give us expert opinion as to whether you think BOSA is justified to say that it would be unlikely that it would survive those tests?

A. I don't think I am, and actually I note that these guys can't give their opinion because they just say "unlikely". But, I don't know, I've not seen or witnessed a partially engaged test, so I can't tell you whether or not it will fail or pass.

Q. All right.

COMMISSIONER HANSFORD: Sorry, Mr Southward, aren't you

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telling us that this situation of cyclic tension and compression, this reversal of load on this coupler, is not something that's going to occur in this situation?

A. Yes.

COMMISSIONER HANSFORD: So whilst what BOSA says here may be perfectly fair, it's relevant to the particular couplers installed at Hung Hom Station; is that your view?

A. Yes, and also a cyclic tension-and-compression test is done outside the concrete. So it's just in free air, and you put the bars in and you pull them, you measure -- you've got marks on the bars and you measure the distance, between them, to measure the permanent elongation. That's all done in free air.

At the moment, these couplers are encased and embedded in concrete.

COMMISSIONER HANSFORD: Yes.

A. So that movement -- the movement won't occur because the bars can't move because they are all encased and surrounded by concrete.

COMMISSIONER HANSFORD: But your expert evidence that you have given us doesn't contradict this paragraph, does it?

A. No, I don't think so, no.

COMMISSIONER HANSFORD: Okay. Thank you.

MR SO: Thank you, Professor.

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Then I would wish to draw your attention to the first paragraph, then, of this page, the first line:

"In response to paragraph 2(b)(i) and (ii), please note we do not have any test data on correlating partial thread engagement of coupler to its structural performance. We have no intention in conducting such tests as it should serve no useful purpose for our products."

Just to confirm, insofar as you are aware, before the tests conducted by CASTCO on 21 November 2018, were there any tests, either by BD or by Leighton or by MTR or by any sub-contractors, that have done tests as regards to partial engagement of threads?

A. I'm not aware of any such tests.

Q. We know that you are an expert in this field. Have you come across any situation where you would test partial engagement of threads into a coupler?

A. No, I mean, I've not had the need to test this situation before.

Q. Have you engaged in testing the strength of a coupler by fully engaging the threads into it, in your past experience?

A. I've not personally seen any testing of these couplers.

Q. In your past experience, not confined to this?

A. Yes, in my past experience, I've not seen or witnessed

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a coupler test.

Q. All right.

CHAIRMAN: But surely, are you -- this is why I'm concerned about this letter coming as it does -- "We have no intention in conducting such tests as it should serve no useful purpose for our products."

That any normal person who is not an engineer would view with horror. Are you suggesting that because a particular item must be placed in a particular way, that you do no tests to see what would happen if it wasn't placed in a particular way? So you are basically saying to the client, "Absolutely, buy it, but if you don't put it in right, we can't guarantee what's going to happen. The roof could fall down." That is ridiculous and that can't be the case, and I don't accept for one moment that is what's meant. What is meant here is, "We are not now going to do some extra special tests for you because that's not our function." That's what's being said, in effect.

MR SO: Of course, then I would wish to add one more point to Mr Chairman's observation, that there are certainly no such tests by anybody before this saga all blew up. There was no test on partial engagement.

CHAIRMAN: We don't know.

MR SO: That was confirmed by the expert now.

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CHAIRMAN: He hasn't. No, he doesn't work for BOSA, but if he does, he should have told us.
Are you employed by BOSA?
A. I can confirm, I do not work for BOSA. I have no relationship with them.
CHAIRMAN: So effectively we are in a position where internationally recognised manufacturers of artefacts for engineering will test them as is necessary to ensure not only that they stand up under correct application but that they have tolerance levels outside of correct application. That must be the case, and I think that we as a Commission can take it that that is what will have happened with BOSA couplers.
Now, was it done in this particular instance? Are they willing to now do it? Clearly not, not in terms of that letter.
MR SO: Of course, sir.
CHAIRMAN: All right? I don't mean to sound overly aggressive but there are certain areas -- and that's why I'm concerned about this letter -- we have to be very careful when it's written and in that context it's written.
MR SO: Of course, sir.
Mr Southward, then, as a matter of common sense, would you agree with me, and as a matter of practical

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science, experiments and experimental results would vary?
A. Experimental results will vary? Yes, of course, they do, yes.
Q. And although conducting in -- all the control factors being at hand, there would still be differentiations between experimental results; would you agree with that?
A. I would agree with that, yes.
Q. Of course, therefore, that's the reason why we have to have more than one test being tested for each control set of variables; correct?
A. Yes. Yes.
Q. Because it would be not reliable in that case, just to rely on one of the experimental results that we have obtained?
A. Yes. As I said, I'm not an expert in statistics, so, you know, as to the number of tests, I can't comment.
Q. Thank you. I bring you back to the same paragraph. I'm not labouring the point that the Chairman has just indicated. I just want to confirm one fact with you.
It was five lines counting from the bottom of this paragraph. There it writes:
"We also understand MTR has conducted various similar tests. So far as we are aware this is the single type of test that has been conducted on couplers

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with partial engagement and the test results are shown in the photo enclosed."
Now, Mr Southward, I just want to confirm, save and except the set of data that you have received from CASTCO, did you receive another set of data from MTR?
A. No. I'm just reading the paragraph above. Here it says:
"Nevertheless, in view of the issue of insufficient engagement of threads ... wish to find out the tensile strength of couplers with various degrees of partial engagement and accordingly, we have provided such samples and conducted tensile strength tests on them and representatives from BD were invited to ... [witness] such tests."
So that implies that that sentence is about the CASTCO tests. Then it says:
"We also understand MTR has conducted various similar tests."
I'm not aware of those various similar tests.
Q. Thank you very much. I just want to confirm that point, that you didn't receive other test results from MTR, just the CASTCO?
A. Yes.
Q. Thank you.
Now I want to move to another topic. Can I bring

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you to OU352.
Sorry, I understand there is a new addition this morning. OU368.
I'm happy to use an old edition, if OU368 is not yet up. I'm happy to proceed with OU352. Let's move on. Let's take a look at OU352.
Mr Southward, I'm sure that you are of course aware of the results of the opening-up?
A. I've been receiving these documents, yes.
Q. Thank you. I want to draw your attention to a few of the test results. The first one I want to draw to your attention would be test 21. Can that be blown up a bit? Thank you.
A. Test 21, where is that?
(Hand indicating on the screen)
Q. Before we start, just to let us have a backdrop of what is happening. I understand that it is BOSA's specification that the threaded length is 44 millimetres long; correct?
A. The threaded length is --
Q. 44 millimetres long.
A. Plus up to 4mm extra.
Q. Correct. That 44 millimetres is what we call a positive tolerance, so it is always about 44; it could not be 40.
A. I understand, yes.

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Q. So the length must be 44 to 48 millimetres?
A. Correct.
Q. Let us have a look at test 21. We can see the engagement length is 35.34 millimetres; correct?
A. 21, 35.34, yes, I see that.
Q. If we give the benefit of doubt of that 3 millimetres, plus or minus 3 millimetres, that would give us 38.34 millimetres; correct?
A. Yes.
Q. And there are no exposed threads, so the maximum possible total threaded length would be 38.34 millimetres?
A. I really don't know, because that's a measurement that's come out of this test, this phased array ultrasonic testing thing. I don't know how that system really works, so whether that's the right number or not, I don't know.
Q. All right. Fair enough. But at least on the face of the results?
A. On the face of it -- so it says zero threads exposed, but where -- you know, what does that mean? Does that mean that there is absolutely nothing and the bar is completely screwed on, or does it mean that the bar -- there's a little bit of thread exposed or the start of a thread?

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Q. Of course. That's a fair comment.
Let me give the benefit of doubt to that too. All right. There is a 2 millimetre thread there, as you said, one extra thread; that would give us 40.34 millimetres. That is still short of 44 millimetres, you would agree with that; correct?
A. Well, 40 is less than 44, yes.
Q. Right. Would you accept that there is such a possibility at the very least that the thread is being cut?
A. I have absolutely no idea. You could equally well say that the bar has been supplied to site with not enough thread.
Q. All right.
COMMISSIONER HANSFORD: Actually, wouldn't it be rather difficult to cut 4 millimetres?
A. I don't know.
COMMISSIONER HANSFORD: Sorry, that's not really a question for you.
A. I haven't done it.
COMMISSIONER HANSFORD: That's me puzzling.
MR SO: Professor, that 4 millimetres has to bear in mind that first I give the benefit of doubt of 2 millimetres for the extra thread that Mr Southward just said, and the benefit of another 3 millimetres of the possible

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plus or minus 3 millimetres of that test. So that would not be just 4 millimetres, in my respectful submission.
COMMISSIONER HANSFORD: Forgive me, Mr So. I think I was just thinking out loud.
MR SO: Thank you, Professor.
Let me just give another example. I wish to labour this point. Can I go to test 48. This is another example. The engagement letter is 33.98 this time; right?
A. 48, 33.98, yes.
Q. Giving the benefit of doubt again, the 3 millimetres, that's 36.98, and again with no threads being exposed.
A. (Nodded head).
Q. You are of course aware of these results.
I would then wish you to go to Prof McQuillan's report, page 117. That's the agreed expert memorandum signed on 18 December 2018.
A. Yes.
Q. I understand this is also one of the memoranda you have signed your name onto, which indicates that you agreed with the content of this agreement; correct?
A. Yes.
Q. Of course, being an expert to this Commission, you are aware that you are allowed to change your evidence or change your opinion if you find it justified to do so;

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correct? You understand that is -- you are of course advised about that?
A. Yes.
Q. Can I draw your attention to paragraph 6 of that memorandum, the second sentence, second chunk of it -- it reads "further opening-up was unnecessary" -- or I will read the whole sentence:
"In terms of the current opening-up regime all agreed, based on the 'redundancy' of the couplers in the bottom of the EWL slab, that further opening-up was unnecessary."
My question is: is that still your opinion?
A. This is in the bottom of the EWL slab and it's based on the redundancy, so yes, that would still be my opinion.
MR SO: Thank you. No further questions.
MR SHIEH: No re-examination.
COMMISSIONER HANSFORD: No, nothing further.
CHAIRMAN: Mr Southward, thank you very much. You have completed your evidence. It's been of very particular help to us.
WITNESS: Thank you.
CHAIRMAN: We would like to thank you very much for your assistance.
WITNESS: Okay. Thank you.
(The witness was released)

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CHAIRMAN: It's just before 1 o'clock. Mr Boulding?
MR BOULDING: I was just going to say that Dr Glover is available but I do see the hour and you may well think it's worthwhile rising a few minutes early and giving him a clean start at 2.15.
CHAIRMAN: Yes. Good. So we will adjourn until 2.15, the same time. Thank you.
(12.57 pm)
(The luncheon adjournment)
(2.19 pm)
MR BOULDING: Good afternoon, sir. Good afternoon, Professor.
CHAIRMAN: I do apologise. One second only. Thank you. Mr Chow, I'm not suggesting that we will have to go through the exercise yet, but at the end of his evidence Prof Au had spoken of a series of mathematical calculations that may assist him to be more certain or more satisfied, whatever the correct terminology is, as to the safety issues.
COMMISSIONER HANSFORD: More confident.
CHAIRMAN: "More confident" would be the word. I'm not saying we necessarily have to embark upon them, but we would like to know what they would be; okay?
I understand that there are two different tranches: firstly, a set of mathematical calculations that should

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be reasonably easy to conduct in a short time span; and secondly, as a fallback, in the case of real concern, certain tests -- okay?
Let's leave the tests at the moment. What we are more concerned with is an outline of those mathematical calculations, put together in a way that people who understand these things are able to deal with, so that we can, if necessary, give directions as to those mathematical calculations.
MR CHOW: Yes. Sir, I am actually in a position to inform the Commission that as far as I know, over the past few days, Prof Au has been working on this and we have got to a stage where the document is almost ready to be served.
I understand that originally there was a deadline imposed by the Commission which was, I believe, yesterday, and we have been working hard on this and I understand that the document is almost ready to be served.
COMMISSIONER HANSFORD: I'm slightly confused by that answer, Mr Chow, because all we were expecting was a list of those things that needed to be done. Are you saying not only do we get the list but he's actually done them?
MR CHOW: No, just the preparation of a list.

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COMMISSIONER HANSFORD: Ah. Good.
MR CHOW: And I've just received instructions that actually the list has been served right before lunch.
COMMISSIONER HANSFORD: The wonders of modern technology. Thank you.
CHAIRMAN: Thank you. So long as it's being dealt with, because we appreciate Prof Au's concerns, and it may be, it may not be, our decision, once we've heard all the evidence, that perhaps, in the interests of caution, if nothing else -- and we make no assessments of anything at this stage --
MR CHOW: Understood.
CHAIRMAN: -- that those tests or those calculations should be conducted.
MR CHOW: Understood.
CHAIRMAN: Thank you very much, Mr Chow.
Mr Boulding.
MR BOULDING: Good afternoon, sir. Good afternoon, Professor. As I promised, I am now going to call the MTR's structural engineering expert, Dr Glover.
Dr Glover, good afternoon. Welcome to the Commission.
WITNESS: Thank you.

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DR MIKE GLOVER (sworn)
Examination-in-chief by MR BOULDING
MR BOULDING: So you have given your name to the learned Commissioners. Please give them your professional address.
A. Ove Arup & Partners, Hong Kong.
Q. You have prepared, have you not, a report for the Commissioners' assistance, and perhaps we can get that up -- ER1, tab 6 -- and look at the cover page.
A. That's correct.
Q. That's the first page of your report, 17 January.
Please go on to page 16. Do we there see your signature above the date of 7 January 2019?
A. That's correct.
Q. Insofar as that report contains facts, are they facts which you honestly believe to be true, Dr Glover?
A. Most certainly.
Q. Insofar as they contain opinions, are they opinions which you honestly hold?
A. Yes.
Q. You signed a joint memorandum. I wonder if we can look at that. ER1, tab 3, page 120. If we could scroll down a little bit -- that's the manuscript version -- is that an agreement which you signed on 18 December 2018?
A. It is.

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Q. Do you still hold the views and agreed propositions which are signed off therein?
A. I do.
Q. So far as you are concerned, were all experts content to sign that joint memorandum?
A. Yes.
Q. Right, Dr Glover. I understand you have prepared a little presentation for us, and that first of all you are going to tell us a little bit about yourself, and then, as I understand it, you are going to give all present a summary of your views. Is that the situation?
A. That is correct.
Q. Over to you, Dr Glover.
A. Good afternoon. My name is Mike Glover, I'm a fellow of the Institution of Structural Engineers and a fellow of the Royal Academy of Engineering. I was made an Arup fellow in 2016, in recognition of the highest design and technical achievements of an Arup person. It's a great honour to have that. I was awarded the 2007 Sir Frank Whittle Medal by the Royal Academy of Engineering, the first civil engineer ever to receive it, and the gold medal of the Institution of Structural Engineers in 2008 for outstanding contributions to the design and construction of major multi-disciplinary projects.
In 2009 I was awarded an OBE in the New Year's

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Honours list for services to engineering. I emphasise "to engineering" because of my wide involvements which are much wider than just structural engineering, although structural engineering is my key skill.
As to the detail of my career -- well, you can do a lot in 50 years -- I had the good fortune of -- yes, I am that old -- I had the good fortune of starting in Arup, who I had the relationship of my career, and I started in Arup research and development. At the time, we were assisting the C&CA, that's the Cement and Concrete Association, in drafting the first limit state code; we used to call it the unified code. That was published in 1972 as CP110, which interestingly enough the existing Hong Kong Code is a direct descendant.
My period in R&D, as I refer to it, coincided with the aftermath of the Ronan Point disaster which Prof Au referred to in his expert report, and I was involved in producing the initial guidance on how we should introduce robustness into our designs. And subsequently CP110 became the first international code to overtly specify requirements for robustness, and those same guidelines are found in the Hong Kong Code today, 40 years on.
I hope, therefore, everyone present can understand why I would like to politely excuse myself from

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attending Prof Au's lectures on the same subject. I'm sorry for that little brief interlude but I think the exchange earlier in the sessions deserved that.
So from the outset of my career, I've had a strong insight into the drafting of guidelines for codes and standards, and most of all the fundamental importance in my career of two things: one is research and the other one is development. You will find that in practically every project I've done. There's always a degree of research and development and experimentation in them.
So, after research and development, I was thrust into the world of high-tech architecture, which culminated in the design and construction of the Hongkong and Shanghai Bank here in Hong Kong, and some of the research that we carried out on that was really quite ground-breaking. Interestingly enough, that's where I first initiated tests on -- not couplers but the hangers that hold the whole building up. Some of them have solid ingots and others are tubes, but they are all screwed, they are all threaded. So one of the big threats we had was: what if they aren't secured?
So we carried out a very, very extensive, full-scale research in the UK to test various levels of engagement. My mechanical engineering friends told me that this was obvious, you know, all bolts, all screwed threads are

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designed to have a level of percentage which is less than 100 per cent, and I haven't got the records in front of me but I think we came to the view after these tests that we wouldn't be happy with 50 per cent but if by accident it happened to be 50 per cent, we could sleep well in our beds.
So this idea of lack of 100 per cent engagement is not a new issue, and indeed our experiments weren't new. I mean, they were just really following in the paths of all those wonderful people who have made screws in the past. So I just wanted to put that into context.
That's the sort of theme of my life. It's really, if there is an uncertainty, if there is an unknown dimension to something, one clicks into a process, and what is that process? That process is, first of all, doing some initial concepts/calculations. The next thing is you do a mock-up or a prototype. Do excuse the people around me, it might just be one. But that one is important because it gives you an indication of which direction you go next. And the next stage is you do formal tests.
So at each stage of the process you are going through, you are actually testing the hypothesis. You don't go immediately to testing things, because that wastes energy, so you walk up to it. The parallel that

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you've got before you now is BOSA have done some calculations, there's an indication that it could be successful, there have been some limited tests carried out, but they are not detracting from the course of direction. And as I will give in my presentation later, MTR are about to embark upon a full-scale test which will satisfy the criteria of the specifications which are set down by various organisations, and I think that will bring a full stop to that issue.

For those doubting Thomases in the audience, yes, it will involve what I think is being called elongation or something -- yes, elongation -- and I will go into that a little bit more in my presentation.

So I make those statements at the outset because they seem to be recurring concerns, so I just wanted to pick up on those as we went.

After the Hongkong Bank, I decided I wanted a change from buildings, particularly working with high-signature architects in that sense, so I did some prime agency work in the oil and gas industry, and we came up with prototype concrete gravity platforms for the North Sea and we built quite a number of them around the world, and I enjoyed that very much, and I enjoyed the prime agency issue, really, the design and taking it through to construction. In other words, having the actual idea

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and then actually making it. I always find the design process, it's only a means to an end, and people who spend their whole life just thinking about design, they have missed something. That's what it is, it is that continuous thinking process which is important in what you do.

But then I got whisked away to be the technical director and the deputy project director for HS1, the first high-speed railway in the UK. I was effectively the chief engineer.

The project, how do you did describe it? 7 billion pounds, and I took it through the approvals process, the design process, procurement, construction, commissioning, and the final handover, to cost and programme. I think that's a theme of practically everything I have ever done in my life. That matters to me. It's that balance between achieving the objective that the client wants both in terms of the artefact but also that it cost him what he thought it should do and he gets it when he wants it.

That project, just to give you a feeling for the scale, 150 bridges, 50 kilometres of very large diameter tunnel under London, the largest tunnels that had ever been -- in fact probably still are the largest, at 8 metre diameter. Our trains go through there, by the

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way, at 230 kilometres per hour, so that can burst the ears if you are not watching out, so we've got lots of vent shafts.

All I'm trying to get across to you is that this is sheer excitement of engineering; that's what matters to me.

Then as soon as I finished that, I found myself being the technical director for the client for let's call it the third Forth Bridge in Scotland, which -- I'm very proud of it, and I'll come on to why I'm very proud of it a little bit later. Again I took that right through from inception, took it through the parliamentary process, in select committees, and right the way through to it getting opened, and that is substantially under budget.

With projects like that, I think you will get a feeling for the emotion and passion I show for what it is, that the things I do are hands-on. I'm a doer, not a watcher. I think that's a very important property to have in an individual.

As to my remit today, to be clear, I've been appointed by MTR to present expert evidence to the Commission on structural engineering matters, and on such evidence I am completely independent, and my sole objective is to assist you, the Commission, in its

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deliberations.

I think that's enough about me, so I'd like to start the presentation, really, in that sense.

CHAIRMAN: Yes, of course.

A. Before I actually start the presentation proper, I would like to share with you some lessons or some particular lessons I've learnt from my experience, and I think they are poignant. They might be at slightly left-field but I feel I want to say them, because I do have a longstanding relationship with Hong Kong and I like mankind to move forward, but I like Hong Kong and I want to see it prosper.

I'm a strong believer that a career should be a constant learning experience, but the only reason you learn for yourself is because you can share it with others, and that's why I want to say just a few words, really.

I'm very proud of the new Forth Bridge. It's world-beating, it's novel in so many ways, and you would think that would be enough. But no, the real achievement, the real success there, was taking a project, when we started, which was estimated to cost 4 billion pounds, but we delivered it for 1.35 billion pounds.

You ask yourself: how do you do that? Is it magic?

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Is it the same bridge? Well, no, it can't be the same bridge, it's just more beautiful. But there are things you do right at the outset which become so important. Some of them might be a little too near the bone for this audience so I will just pick on some of them. Some of them were very innovative engineering. Maybe you would expect that from Arup, but actually it comes from a freedom of thought, not crushing things. It's fundamentally creating a single focus on delivering the project for whoever is involved in the project.

COMMISSIONER HANSFORD: Sorry, did you say not crushing things?

A. I'll just elaborate on that.

COMMISSIONER HANSFORD: Okay.

A. It is crushing, yes.

COMMISSIONER HANSFORD: That's fine. Thank you.

A. You've got to get people -- I call it the flag on the hill -- you've got to get every member of the team -- and the team is not just the people who are the designers or the specifiers. They are the approvers, they are the third parties, they are the community; you've got to get everybody -- it's hard work, but when you do that, you've got everybody aligned. Everybody can see the flag on the hill. There's no them and us. It's them and us that costs you money in projects, but

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if everybody is rooting for that objective, it's quite remarkable how the pounds, or in this case the Hong Kong dollars, fall away.

So that's fundamentally important, but one of the subsets of that is that you must challenge compliance rules right from the outset, because those are the things that crush ideas at the beginning, and if you don't have the ideas and the enthusiasm at the outset, you will never get them as you go through.

So all I'm saying is the best projects in the world, the projects that create great engineering, are ones where everybody is pulling in the same direction, and if you find any situation where someone's pulling in the opposite direction, if you're a client, you sort it out, because it's going to destroy the project.

So I'm sorry about those thoughts. Some people might think they are completely left-field. But I feel very passionately about them and they are the hallmark of what I do with my life.

COMMISSIONER HANSFORD: I think they are very helpful.

A. Thank you.

Now to my presentation. I'd like to make it clear that in my opinion, the structure is safe, and I will try to explain the reasons why I formed that opinion in this short presentation.

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My report and this presentation are looking at the design and construction on a strictly fitness-for-purpose basis. I'm not seeking to demonstrate compliance. I'm just trying to demonstrate safety, on the basis of fundamental physics and experience.

The first thing I would say, that ho hum -- sorry, Hung Hom. I'm sorry, I nearly broke into song there. I didn't mean to. It could be a good one, couldn't it?

CHAIRMAN: That's a very interesting malapropism.

A. It's a very unusual structure and I've not heard people referring to it as being unusual. People just look at problems and things but I look at it as a structure. It's quite unusual for a number of characteristics and I'll try to pick out a few of those as we go through.

But I think some of the issues you've been confronted with are a direct product of that. There's a danger of always looking at construction and saying there's this in construction, but it's not. It has its roots right the way back in its concept, right the way through its design, and all you're seeing is the end, the result of that process.

With that as the backcloth, maybe I could go to the slides.

MR PENNICOTT: On the screen.

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A. Do I just say "next slide"?

Next slide, please. I haven't done this for ages, saying "next slide". It's quite refreshing; I'll have to try to think about this.

I'll deal with the project by going through a whole series of headings, and these are headings that I can speak to, but they are at the heart of what the project is about.

Prof Au says in his report, in paragraph 6.1.1, that ductility is a desirable quality in structures. I would go further than that. I would say, firstly, the Hong Kong Code is misleading in the sense that it has a section called "Ductility". In other words it's implying that if you don't do this, you don't get it. Well, that's absolute nonsense, because all reinforced concrete is ductile, provided the tension, the reinforcement, is what controls the design. In other words, the steel components should be slightly weaker than the concrete, and in that case, whenever you have a bending moment or something, the first thing that starts to yield is the steel.

So you don't need a special clause called "Ductility". That's the first thing that I would say. I don't really understand why that should be mandatory. But I'll go on to why I think it's there. It's because

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the sort of detailing that you are seeing in that particular clause, 9.9.1.1, is the sort of detail we would use in real seismic areas, and Hong Kong is not a high seismic area. And the reason why you have those particular details is because you get what we call stress reversals. In heavy ground shaking, things move backwards and forwards, so something that was in tension becomes compression so you get that action (demonstrating with hands).

Well, that won't happen in Hong Kong and it most certainly won't happen with a rigid box sitting in the ground. So I think there seems to be a slight misapprehension as to how to apply that particular clause to this type of construction. That's my opinion.

Could we go to the next slide, please. I just wanted to explain to people what ductility is, and this is going to be difficult without a pointer but I'll try my best.

COMMISSIONER HANSFORD: You can get a pointer because the operator can put a little hand on.

A. Could you take it up to where the 560 is and where it links across to the yellow. That's it. That's what we would call the notional yield point. If you loaded something from zero, it would go up to about the 560 and then it would follow the line back again when you took

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the load off. That's what we call elastic. So you load it on and it comes back.

We say that's recoverable shortening or deflection. So that's the elastic zone.

If you then take the pointer from that point and move it to the right -- there it goes; keep going, right to the end -- where the pointer is going is the plastic portion of the curve, and ductility really is the ratio between the elastic portion and the ductile portion, and this one, looking here, it's probably a ductility ratio of five. In other words, you can get five times the energy absorption out of a plastic zone than you do out of the elastic.

And why the plasticity is so important is because it's absorbing energy. Normally, if you want this building -- if this building was, I don't know, you took your pet hippopotamus walk across the floor, it would deflect, but you wouldn't want it to stay there, you would want it to come back, so it stays in the elastic range.

COMMISSIONER HANSFORD: Sorry, if you took what for a walk across --

A. A hippopotamus. I chose a hippopotamus rather than an elephant, because a hippopotamus, you could get it through the door, but an elephant you would have some

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trouble with so I try to keep the scale.

So that's appropriate. Under normal loading, you would want there to be no permanent deformation.

Take the case where you have a very strong ground motion from an earthquake. There you want survivability of the occupants, so therefore you can accept permanent deformation. Some of it, if it's a small amount, it could be recovered and you can use the building again, but normally it would be demolition.

On the next slide, hopefully -- yes, here we are -- the codes talk about critical zones, plastic zones, and these are shaded on the top diagram, and these are where these plastic hinges occur, which allows the structure to sway, as shown as the bottom.

If you go to the next slide, you will see that's not what we've got. We've got a really substantial stiff box, which actually, if there is -- and the earthquakes you get in Hong Kong will tend not to be of long duration or -- they will be high energy but they tend to be in the high frequency areas -- so the box is really held very steady, and the ground would dampen any large movements.

This is the experience around the world. Box structures have survived very, very heavy ground movement, remaining effectively in their elastic zone.

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It's because --

COMMISSIONER HANSFORD: Where, for example?

A. California, for example. I don't have experience of Japan so I'm not going to go that far. Japan is very, very seismic, much more seismic than California, for example.

So assuming a box like that is seismically sensitive in an environment like Hong Kong is not correct.

But I'll use that particular slide to explain some of the reasons why I say this construction is a little bit different. It is because if you see the arrow that says "EWL slab" -- well, that slab is 3 metres thick, and that's very, very exceptional for a suspended construction. We wouldn't maliciously do something like that. There has to be a reason for it, and that's what makes it exceptional. The reason in this case is we need to get as much deadweight, vertical weight, as we can to stop uplift, because -- there are no dimensions on this but the underside of the lower slab, called the NSL slab, is 15 metres below ground, and groundwater is potentially near ground level, so you've got 15 metres of water trying to push this structure out of the ground, and so the only way you can fight against that is by using mass. The Hong Kong codes don't allow us to use what we call adhesion on the side of things; we have

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to use mass. And so therefore we have to find something equivalent to 5 metres of mass in the construction to keep the water down. The way that is done is a 3 metre slab at EWL level and a 2 metre slab at NSL level.
COMMISSIONER HANSFORD: Why that way around?
A. This was a design decision, as I understand it, and it was that there was sufficient headroom between the NSL level trains and the EWL that they could use that depth.
If they had done it the other way around, we would have had to go deeper, because -- a lot of people don't realise this but trains don't just go up and down hills, they have very controlled gradients and so the line the trains come in on the NSL, that's the level it has to be, within a few metres.
COMMISSIONER HANSFORD: I see.
A. So really the decision to put the 3 metre slab there, although it is extremely unusual, the engineering justification for it is very, very sound and very solid, and interestingly enough, even -- although I had shock horror of seeing it in the first place -- I can understand the logic of it and I wouldn't contest that idea.
But it does generate its own issues, and some of them very positive, actually.
So that's what makes this one particularly special,

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the geometry.
The second thing that makes it very interesting -- and this is why a lot of people are saying they don't believe the utilisation values that are being talked about -- is it's a structure which has two lives. The first life is when it's being constructed, and that is where the EWL slab that you can see on the slide has no other supports, other than the two diaphragm walls on either side. So it's free-spanning. And during that condition, it's subjected to the most onerous construction loads, not just because it's spanning circa 24 metres but because it's got all the soil coming out, the heavy plant dragging the materials out from underneath.
So, as a consequence, the slab to a very large extent experiences its worst loading case.
COMMISSIONER HANSFORD: During construction?
A. During construction. Once they have dug down and they have formed the NSL slab, you notice that there's a couple of green lines sticking up.
COMMISSIONER HANSFORD: Yes.
A. Well, they become secondary columns and supports. So the second life of the EWL slab is one where it is in a much more benign environment, where it's undergone its worst conditions and it's got vertical supports.

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COMMISSIONER HANSFORD: Albeit quite a thin one.
A. That one looks thin but there are some more substantial.
COMMISSIONER HANSFORD: Okay.
A. You've got to remember, when you build something into something that's already there, there are locked-in stresses and locked-in deflection. I wouldn't want to alarm you. I mean, a 3 metre slab spanning something less than 24 metres is more like an arch -- it's going to turn into a lecture, I've got to watch out -- but that's one of the other issues about robustness. People normally -- and I think Prof Au used the term a catenary, you know, you -- with a thin slab, it certainly would go into a catenary and -- that's what it is. But a structure like this, the fire -- the structure expands and really it tends to arch. You know, it can --
COMMISSIONER HANSFORD: Perhaps colleagues will excuse my enthusiasm for this but I'm rather interested.
A. Well, that's the way the structure works. And believe me, this structure's got plenty of -- I use the definition very appropriately here it's got plenty of robustness; it's not going anywhere.
So I thought, to give some context to some of the issues, it would be worth just explaining some of that to you.

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If I could move on to the next slide now and talk about seismicity. I just want to -- I won't spend so much time on this one, because nobody is contesting the fact it's a low to moderate seismicity. The Hong Kong Code doesn't even have a chapter on it. MTR in their wisdom have got a nominal load of 7 per cent G. 7 per cent G on a world scale is very, very nominal load; it's not -- it's a prudent measure. Interestingly enough, something like that would be much more important on an elevated bridge or something, but something in the ground, I wouldn't say it's token; I think "nominal" would be a better word. But as I've said earlier, sub-ground structures, like the box, perform extremely well in earthquakes, if you can perform very well in an earthquake.
The other thing I draw -- I did do, and I do apologise for the quality of my calculations, I'm getting a bit older now, but I did include a calculation in appendix C to explain why the EWL slab never becomes ductile; it remains elastic, no matter -- even if you did have a California-type earthquake, it's just not physically possible to become a ductile structure. So the idea of using ductile couplers is clearly just not appropriate. I mean, by all means use ductile couplers, because they are very robust and they don't seem to cost

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a lot more than the other, but they are not serving a function of ductility.

The other important thing is because of its sheer mass and because of the fact that it sits in this box, it means that it doesn't undergo stress reversals, as I was saying about the things (demonstrating with hands); it only knows about either direct tension or direct compression.

The other thing to emphasise is that the base, the bottom of the slab, as it joins the wall, is permanently in compression. With all due respect to Mr Chow earlier, the idea of there being a sagging moment to the support, I hope that you understood what we were saying about load combinations. That particular -- I think it's called PERM 5 -- it never exists as an individual situation. It's only a component. And if necessary, if you wanted me to, in discussion, I could explain a little bit more, but it never goes into sagging and indeed Prof McQuillan's diagram, you should stay with that as your knowledge base, I think.

So if I have the next slide, I think, please. Oh, that's the calculation which I apologise for, so we can skate over that.

COMMISSIONER HANSFORD: You are only apologising for your handwriting, are you?

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A. No. I'm not trying to hide any errors on that. I'll take you through it if you want me to. Are you sure? I'm quite happy to.

COMMISSIONER HANSFORD: I made the point yesterday that I think it's unwise for lawyers to get into structural calculations.

A. I don't know, you may want to change career.

Could you go to the next slide.

You've heard a lot of strength utilisation and basically it's the ratio between two numbers. One is: what is the maximum strength of this component on the bottom, and on the top is, what is it actually being stressed to at the moment? It's just a simple ratio. And it's a measure, obviously, of how hard the structure is working. A high percentage means it's working very high and obviously a low one means it's not working very hard at all. I'll illustrate that a bit later.

If I could go to the next slide, please. This is just to emphasise why I have the confidence in the utilisation values. Atkins, the designer, have covered every single element in the structure, as you would expect, and they have come forward with generally -- I say generally low -- less than 50 per cent, let's call 50 per cent of the benchmark. There are a few areas where there are hotspots, what I could call, but none of

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them are distressingly high. I'm a great believer in not having exception solution designs, in other words don't design for the maximum. You've got to design for something lower than that and deal with the maximums. But there are no maximums that I've found or that Atkins have drawn to our attention that would cause alarm in this structure.

COMMISSIONER HANSFORD: The reason you say you are a great believer in not designing for the maximums, Dr Glover, is because presumably, if you design for the maximum, you are always overdesigning and it costs a lot more?

A. It costs a lot more. It costs a lot more time. There is a lot more that can go wrong. I've always tried to bring my team up with the attitude of do the simple things simply to buy time for those things that we know we're going to deal with, otherwise you are just caught out, you know. The other thing -- you really are starting me off now -- you've got to do at the outset of any project, you've got to be very honest about what you don't know. If I was to think about what the most important thing about starting a project is you sit down with your key team and say, "What don't we know?", because those are the things you've got to embark upon your research programme then.

So often you see with projects people bump into

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something later on and it's too late. You know? I'm not going to say I'm infallible, please don't take it as that, because that's the quality of the team, no individual is strong enough to know everything. But if you've got the right team, and I don't just mean those people around you, but those people who positively think about the flag on the hill, then you rarely go wrong.

Both ourselves have carried out spot-checks, as Arups, and COWI's report I thought was -- condescending slightly -- a good effort, but I thought it was well-conceived. They drew attention to 161 stress, as a good engineer would do, just innocently saying it's a boundary condition and suddenly a bonfire is lit.

But, no, I fully understand the way it was modelled and you've got to cut a model somewhere and there's a discontinuity in it. I get that.

We all find that we arrive at about that sort of 50 per cent level, and some areas are actually lower.

The next thing which reinforces my belief about these low levels is when you build a diaphragm wall, you put, let's call it, tubes. You cast a tube in the diaphragm wall.

COMMISSIONER HANSFORD: We've been referred to tremie pipes.

A. No, that's --

COMMISSIONER HANSFORD: That's different.

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A. That's for pouring the concrete.
COMMISSIONER HANSFORD: Okay.
A. You put -- interestingly enough, when you look at a modern diaphragm wall, you think it's a piece of scientific investigation. It is, in fact, because we put tubes in for inclinometers, let's call it a gyroscope, and the gyroscope measures the shape of the tube, and so by integrating the rotations, basically, you get deflection.

And so through the life of the construction, if you drop the gyroscope down at weekly intervals, you get a record of how the wall is moving. Some of the other holes are for acoustics and other holes are for grouting the base.

And so we've taken a number of those inclinometer readings and they are all remarkably consistent that there's hardly any movement in the wall. When I looked at them I thought have they been out there measuring them, but we've looked at about -- please don't hold me to this, but well in excess of a dozen, and they are all showing very low movements, and in fact, in some cases, you reckon, on the depth of the walls we've got, a tolerance of probably in excess of 5 millimetres, plus or minus, thereabouts, and we are recording movements of about 15, I think, that sort of number.

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So what does that mean? It's good news. It's lovely. It really means, if you're not getting movement, you are not getting bending moments. If you're not getting bending moments, you're not graunching things, you're not applying load.

So the utilisations that I mentioned to you earlier are all to do with calculated analyses. They are predictions. But on the diaphragm wall, what I'm saying to you is we can reduce those predictions I think with a great degree of confidence.

COMMISSIONER HANSFORD: In your view, in your experience, is that due to design or is that due to construction?
A. No, it's due to the assumptions. You could call it design. In Hong Kong, they take an extremely conservative view on the ground parameters.
COMMISSIONER HANSFORD: Right.
A. Because a site investigation is carried out, doing boreholes and taking measurements called SPTs and CPTs, and from that you can derive a model of the stiffness of the soil. Then you have to make a decision where you draw a line, because there's scatter on those results. So do you draw the line down the middle, do you draw it optimistically or do you draw it pessimistically? Hong Kong being prudent, the BD and GEO, would tend it to the lower line. One of the reasons for that is

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prudence. The other reason is that they have had some bad experiences in the past, but I think those bad experiences are not to do with the soil parameters, they are to do with contractors not putting props in at the right time. But there we are. But don't start me on that issue. I will move on.

So there are all sorts -- basically what it's saying is the soil is a lot stiffer than was expected. And I've already said to you that there's a large reserve capacity in the bottom of the slab, really, based on, really, purely structural considerations. But having said that, we would make sure there was enough steel in there for robustness. There we are.

Could I have the next slide, please. I just wanted to really touch on what that 50 per cent meant. I think I've described to you this curve just now, but if you look at the "460 characteristic strength", that's what the discussion has been about, what is the bar that's been used on the construction, and it's interesting on this curve, this must have been a 500 bar, because you can see it goes above the 460.

But we only design to 400, so although if a bar is 460, we reduce that by using material factors to 400. So when we talk about ultimate limit state, we are designing at 400MPa. But because of our load factors

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the maximum the structure would be working at is the 260. That's the working stress. That's if you've got the full load and the minimum amount of steel required.
COMMISSIONER HANSFORD: This is irrespective of the grade of steel used?
A. No, it would be proportional. So if it was 500, then it would be a ratio of -- 10 per cent higher, probably 300. And I've taken a 460 bar because that's what it is.

But if you take 50 per cent utilisation, the stress levels in the bars, they are down at 130, and throughout our structure -- I say "our", I seem to be possessing it now -- the levels are even lower than that, and if I take into account the results from -- the inclinometer results, you are probably down in the 60s and whatever.

So these issues that you keep hearing about, is it going to crack or whatever -- well, I just can't see how, to be honest, under loading conditions. There are reasons you get cracks and they're not necessarily to do with loading. They are to do with shrinkage. They are due to all sorts of little features. But there's nothing -- I've seen nothing alarming in the superstructure or the diaphragm walls in my walk around the site at all.

Could I have the next slide, please. This just gives you the scale -- sorry, the yellow line is the

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predicted deflection, and I call it the "Arup modified model" because we took the Atkins model and we made a few little adjustments for ourselves, you know, carrying out checks.

So we were predicting -- let's call it 45, I don't want to be alarmist at 50, but the green and blue lines are us trying to work out what the actual stiffness of the soil is based on the inclinometers. You can see there's quite a dramatic difference, in fact more than I would have thought. We are about a third. Normally in Hong Kong, other experiences are that it's about 40 per cent, but this is a bit -- it's in the bounds of expectation but it's lower than even I would have thought.

Moving on, please, to the next slide.

Basically, the discussion, while I've been here anyway, has always been about the coupler connections, and they are really -- they are in the top and the bottom of the construction, as we all know.

As far as the EWL slab is concerned, there's only a few areas of couplers in the top. I say "a few areas", there are ten individual panels or parts of panels. And why are they there? They are there because of the sequence of construction. There was a whole series of underpinning works that had to be done early.

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So when the contractor started his alternative design, those temporary works were already in place and he couldn't replace them.

So generally the top of the EWL slab is the contractor's alternative design, and I make no apology for saying that in my opinion it is a superior detail. I'm not going to say anything more about construction joint. I think everybody has trampled over that enough and we will see, as the Chairman says, what the calculations show.

It's because of the geometry in the slab and its massive weight that the bottom is always in compression. You just can't avoid that. It doesn't matter how you look at it. If this had been a 300 millimetre slab, a tenth less, then there's every opportunity for a loading over here (demonstrating) causing the slab to bow upwards, in other words to have tension in the bottom. That's why in thinner slabs we do put reinforcement in the bottom, just against that. Take my pet hippopotamus going for a walk on one span; that would definitely make the other one want to come up a little bit. But those loading cases don't apply here. This is a massive piece of construction.

The other thing I want to emphasise, in the last bullet point, there's no cyclic loading on those

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connections. There's a slight variation in tension, as Mr Southward pointed out. When a train, in a normal situation, would go by there's a slight increase in stress, but it's just a little bit. It's not cyclic in the sense you're going backwards and forwards.

And the point that I've got to emphasise again and I don't want to bring up the earlier slide I showed you -- the trains on the EWL slab effectively sit on the D-wall, because the slab extends across it --

COMMISSIONER HANSFORD: In some cases slightly off.

A. Yes, it is. On one side you've got one wheel firmly on it and the other one slightly off, and on the other side it's right parallel to it. So it's not going to give you large vibration. It's going to give you -- because to get vibration, you've got to excite something, and to excite something you've got to be in a position where you can bounce it.

So I've got no concerns about cyclic loading. In fact, it would be criminal to consider things like cyclic testings on things like that. I mean, you can go all sorts of things --

COMMISSIONER HANSFORD: Criminal?

A. It's criminal because it would mean that you would be rejecting an opportunity to use something. You are being malicious in your rejection of something which

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would otherwise be sound.

COMMISSIONER HANSFORD: Interesting.

A. I mean -- did I explain it well enough?

COMMISSIONER HANSFORD: I understand. Yes.

A. Could I have the next slide, please. This is to just to emphasise, really -- and I still don't understand why we've got the same amount of reinforcement in the bottom as you do in the top but I think that's -- it's not -- I think it's best to pass over that really. Could we just stick with that one for a moment, because this diagram, I didn't realise it would show this quite so well -- you see the shear key, and you saw the photograph earlier, where there was this concern about was that A shape or whatever? Well, if you look at the four couplers at the top and you strike a line across under soffit of the four couplers, it coincides with the shear key. So what you were looking at in that photograph, on the right-hand side of the photograph, was the exposed reinforcement on the inside of the slab, where that blue line is on the inside, going through the shear key. So that's why it looked as if it was going like that (demonstrating); it was because actually it was a vertical cut to form for the shear key. That's my guess but I think it fits and I didn't realise this would do that quite so well.

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Does that make sense, sir?
COMMISSIONER HANSFORD: I think we might want to revisit that point slightly.
A. I didn't mean to bring it in.
COMMISSIONER HANSFORD: No, no, no, I don't want to interrupt your presentation, but there is a flip-chart here, and maybe at a later stage, if appropriate, we will see how that A shape might fit with this.
A. Okay. Look, believe me, I fully support Mr Southward in terms -- I like As. As long as the surface is prepared -- I mean, people think it's got to be like that (demonstrating), but what about the construction joint that there was going to be against the diaphragm wall? That's vertical. You know, is that bad news? No, it's all to do with the preparation of the surface which is very, very important.
COMMISSIONER HANSFORD: That's fine.
A. And the other point that's come out in the discussion is the doweling action that you get, you know, it controls all sorts of things.
Anyway, next slide, please. And I think this one probably does show what I was just saying quite well, actually. If you see the blue area, it almost does coincide with the shear key. But again I emphasise I'm very happy with that detail.

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Next slide. Now the coupler characteristics. I mean, there's a lot of talk that goes on about ductile couplers. Well, type I couplers are ductile. The stress/strain curve I've just shown you -- twice, I do apologise for that -- that is the stress/strain curve for a type I coupler. So type I couplers and type II couplers are ductile.
The difference is that a type II coupler can take the seismic loading, can take the stress reversals, and that's really why, as Mr Southward said, if you are in doubt about future environment, fatigue or whatever, then you would put a type II in. It might not -- it probably won't ever know any cyclic loading. So I'm perfectly happy to see type II couplers in there, but what I'm not so happy about is people suddenly putting baggage on that decision and ascribing all sorts of things to it which was never intended, like cyclic loading: we've got to have this because it's got cyclic loading. Well, it hasn't. It's perfectly happy sitting there, taking direct tension or direct compression.
I think that really is -- for my fitness-for-purpose basis, I'm quite happy for just direct tension and direct compression and I don't wish to hear cyclic testing mentioned again in terms of their fitness for purpose, because it's not appropriate.

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COMMISSIONER HANSFORD: I fear you might.
A. Okay. I'm sure I might but I'm used to that. 50 years makes you a bit impervious to some of these things.
Could I have the next slide, please. Now, the strength characteristics -- I did say to you earlier about some of the earlier research I did in my life, so I wasn't surprised with 60 per cent. In fact, I think if you were pushing it you would go to 50. That's why I'm happy with 60, because I think it gives you a prudent reserve.
But I'll come on to that later. It requires this next stage in my three stages of arriving at the full stop, which is proper testing. And indeed they are -- MTR are embarking upon the testing programme that I would expect, which would be nine specimens of each engagement, and statistically that is what you would use in a production engineering situation. If you are looking for whether a batch is strong enough, you would tend to take nine samples from something in excess of -- I think the overall I used to use was -- anything in excess of 500 as a batch, you would take nine and you would test them, to demonstrate that the batch was good, and that would hold for even larger numbers, 1,000, 2,000 or whatever.
COMMISSIONER HANSFORD: You have been appointed by MTR, but

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of course you are independent.
A. Yes.
COMMISSIONER HANSFORD: But I don't think we've heard about these additional tests from MTR. Do you know when? Have you been told when these are happening?
A. I think they are very imminent and I think these have been discussed with BD. I don't think they've just gone out on a limb.
COMMISSIONER HANSFORD: Perhaps Mr Boulding will tell us about that at an appropriate stage.
A. Yes. I'm sorry if I --
COMMISSIONER HANSFORD: That's fine. This is very useful.
A. I'm quite excited about it, actually. It would be lovely, pulling things apart, getting to the bottom of things, that's what you want, stop talking about it and do it.
Anyway, subject to the successful outcome of those tests, I think 60 per cent engagement -- where do you go after that? You've done everything you can.
Sorry, next slide, please. Oh, yes, I had to put this one in. I do apologise. This is another example of where following the rules will trip you up. The NSL slab has been designed as a suspended slab -- I only brought this up because it came out in discussion I think yesterday. Mr Chow, you brought it up, I think.

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The slab is designed as a suspended slab, so therefore it's a suspended slab as far as the world is concerned. That's like me saying black is white, because physics has a way and natural life has some other ways of telling you that it doesn't matter how you've designed it, it's how it will work, and if you cast a slab on the ground which has been surcharged for over 50 years by soil which is 15 metres deep, which is probably approaching 3 tonnes a square foot, you are going to assume that that's going to settle under the slab? There's more likelihood it will swell.

So designing it as a suspended slab is effectively putting an air gap under it. Now, you say, okay, that's conservative, and the water is going to come along and lift it up and that's all right. But the problem is that slab is connected into the diaphragm walls on either side, so the mathematical design assumes the slab deflects or pulls the wall over in a hogging fashion, and then when you put the water on, it pushes it up, but the datum point for the pushing up is in this sag position. I can do a sketch to explain. But what it is: it's unsafe.

COMMISSIONER HANSFORD: A sketch would be helpful.

A. I'm not very good at drawing.

COMMISSIONER HANSFORD: The next page.

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A. I don't want to spoil that.

Of course, that's evidence of what was said.

COMMISSIONER HANSFORD: Do the drawing first.

A. Okay. Let me do the drawing.

(Drawing on the whiteboard) This is the diaphragm wall. A shear key. Very important. A slab.

COMMISSIONER HANSFORD: This is the NSL?

A. This is the NSL, I'm sorry, yes. And ground.

Now, if you design it as if there's an air gap, and believe me it's going to be fictitious, the slab will tend to go like this (demonstrating with hands). At that point, it's hogging, but it will sag down.

What that does is it pulls this wall, it puts a bending moment in the wall (drawing an arrow).

Now the water comes along and we are talking about 15 metres of water, which is pretty considerable, and the slab does this (drawing arcs), and it then pulls the wall that way (indicating).

The problem with that is it started from a position that was down here, so let's call that M1 and that's M2. So the difference is M2 minus M1. But the reality is M1 is zero. So the fact that you assumed it was sagging, put a bending moment which was fictitious into the wall, so when the real pressure came on, you were found -- in fact, this is really why, if you look at our Plaxis

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report that we did, the bending moment down here becomes more critical than the bending moment up there.

So it was a near-run thing, mathematically, but fortunately the wall never moved anyway. But it's a warning, really, of where following rules is daft. You've always got to ask whether the rule is appropriate. That's all. That's all I ever ask. You know, rather than, "You do it that way or you don't do it at all" -- I mean, that doesn't make any sense.

COMMISSIONER HANSFORD: Are you saying following rules blindly is daft?

A. No, I say "following questions unquestioningly". No, the blind is not -- unquestioning is a much better way of doing it, because I'm sure everybody wants --

COMMISSIONER HANSFORD: No, I was just trying to understand. You weren't saying following rules is daft?

A. No. I think rules are important in any society. But you've got to understand whether the rule is appropriate, and you can only do that by asking questions, and if the other side turns around to you and says, "That's the rule", then we've got a real problem, haven't we, as a society? A society that doesn't understand the fact that you don't always get it right because it's written down. It doesn't always apply.

COMMISSIONER HANSFORD: We'll leave it there.

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A. That's all. I can only speak as I find, really.

Okay, so if we keep going with that, I think I've covered -- oh, it was interesting that Prof Yeung brought that up in his expert report, in fact at 135, and I think he probably described it better in words than I could have done. So it's not just it was our observation through our analysis. He had the same concern. I don't know whether he's here -- anyway, I thank him for drawing attention to that.

Next slide. So "Conclusion". There's undoubtedly issues of workmanship with the coupler connections, and they've got to be addressed and put to bed. Whether I think they are exceptionally high, I wouldn't go as far as saying exceptionally high. I would say that there are issues, and clearly couplers that are only 6 millimetres engaged or 9 millimetres was a bit of a surprise, but if you look at them, it's not a question of work being malicious. The bar is there; he's done his best.

My experience through life is operatives generally want to do a good job. They don't get up in the morning and say, "You know what, I'm going to cut ten bars today." You know, people want to do a good job. And interestingly enough, good operatives -- and the construction industry in Hong Kong still has good

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operatives -- they know that if they do the job right first time, it's the easiest thing in the world. Bodging costs time and runs the risk of you being identified as an individual and having to do it again.

COMMISSIONER HANSFORD: But it helps if they can see the flag on the hill.

A. Absolutely. Toolbox talks, in the morning: "What did we do yesterday? What are we going to do today? Could we do it better?" That's the spirit. That's what you've got to do.

Anyway, I don't want those issues to cloud this one of safety. The construction, really, of that station should be allowed to continue, because when you think about it, every day you are denying society an asset that it can use. Why? There's physically no reason from a technical point of view why you can't do that.

I would go -- and I say why -- I mean, technically the structure has a very large reserve of strength. I look forward to seeing the calculations for the construction joint, and if necessary I will join in the debate -- I've stayed out of it at the moment because I think there are people who have enough knowledge to deal with that. But, as Mr Southward pointed out, there's no evidence to show any distress whatsoever.

Anyway, to my very last slide -- you will be glad to

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hear that -- "Way forward". I seriously think we should review the scope of the opening-up. It doesn't involve me as an individual but I think we have something like 80 areas opened up. I think that is more than enough. My earlier reports show that that's more than enough to establish a trend statistically, whether it's 37 you are interested in, 32, 26, there's enough there.

Opening up more will not change that picture, to the extent that it is statistically important. You can't stop it today, and maybe you don't have the authority to stop it, but what I'm saying is I think it's increasing the nihilism of the whole process, really, to continue it, but that's for other people.

COMMISSIONER HANSFORD: And is it damaging?

A. Well, with that reserve of strength, I've got to say no, but you've got to repair things and the idea of even digging out the second layer or the third layer or the fourth layer -- you won't get any better data than you've got now, and the data is -- it shows you a range of responses. What do you expect by opening up more? Is it the "I told you so"? I mean, it's not going to happen. And the police have enough information now, I would imagine, to establish there is either a case or there isn't. Opening up -- if you found one or two or whatever number of, let's say, wrongdoings, for example,

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how does ten help you?

So the continuing process, you've learnt what you've learnt. The reason why -- the other reason why I want to possibly hopefully make a plea for stopping the opening-up is because then we can get back to building the thing and finishing it and getting it operational. That's where I'm coming from. It isn't, "You are weakening the structure further."

COMMISSIONER HANSFORD: I understand.

A. Just think of how much value that is to society for every week that goes by. Why do it? There's no reason.

Anyway, the last point is the stage 3 holistic proposal re-analysis that we are doing. We've actually started now.

COMMISSIONER HANSFORD: Sorry, who?

A. Sorry, I should explain. The holistic proposal had a stage 3 to it, which was the re-analysis of the structure --

COMMISSIONER HANSFORD: Yes.

A. -- using the as-built information and the best information we have available. Indeed we and Atkins and -- we've started that process now of compiling our basis of design and making sure we've got the right records to be able to do it. So we've started on that.

MR BOULDING: Good.

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A. Is that -- that is it.

Q. Thank you, Dr Glover. I just have a few questions by way of clarification. This proposed stage 3 of the holistic proposal, I want to be clear about the intention. Will that include direct force and elongation tests on the coupler assembly?

A. Yes. I mean, the tests -- thank you very much for that -- the test we intend to or MTR intend to carry out, as I say, is nine samples, covering direct tension and compression, and the elongation -- I would like you to know that the elongation is the width of your hair, 0.1 millimetre.

COMMISSIONER HANSFORD: Yes.

A. That's the level of concern we're having.

COMMISSIONER HANSFORD: Not the width of mine.

A. Interestingly enough, if you were in Texas, for example, you wouldn't have 0.1, you would have 0.25, and I think California is another number.

What I'm saying is the 0.1 is a measurement of the product passing. It's not a structural integrity issue. It's an indicator of what that thing does, because when you imagine it, this test is done in the open air, but the thing performs inside concrete, where it's bonded in and it's bound.

So this thing about elongation -- yes, elongation

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will be included, but not cyclic. That would come under the heading of malicious.
MR BOULDING: I've got one other matter, and the people who put things up on the monitor are very clever -- I wonder if we could have slide 19 up at the same time as we have photograph B19/25587, because do you remember you were asked about the photograph that I think Mr Chow was discussing with one of the witnesses earlier?
Then if we could have your slide 19 up alongside that.
A. Yes. In fact, could you show the cross -- is slide 19 the cross-section?
Q. The cross-section?
A. Yes, the one that shows the couplers, the green one. That one will do, yes.
Q. Now, can you explain --
A. What we are looking at?
Q. -- what we are looking at?
A. The photograph is taken -- this is a supposition on my part, but looking at the two side by side, I think it explains it quite well.
The photograph is taken standing slightly outside the line of the diaphragm wall. The right-hand side of the photograph is inside the diaphragm wall -- sorry, is inside the excavation.

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So when you look at the blue bars --
COMMISSIONER HANSFORD: Sorry, is this therefore the reverse of your green diagram?
A. Yes, that's right, it is. Thank you for that. That's a good way of explaining it.
COMMISSIONER HANSFORD: A mirror image.
A. Yes, it's a reflected image. It's almost like it's a book being opened up.
You'll see the blue bars on the right-hand side, and you can see that they go down the hole, as it were, the slot, and you can see the binders that I talked about, the stirrups.
MR BOULDING: Does the colour blue signify anything?
A. No. This is a corrosion and bonding agent that they apply to the exposed diaphragm wall steel when they cut it down.
Q. Right.
A. So when they cut out the shear key, they would have applied this coating, as I say, anti-corrosion and bonding.
Q. Anyway, what, if anything, does the photograph show you?
A. So that line, if you drew a fictitious line on the left-hand diagram, you would see that if you took the top of the shear key and you extended it to the right, that would explain where you get the slot. So that slot

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that you are looking on the right-hand side I think is the shear key. It seems to match, doesn't it?
MR PENNICOTT: I see it.
A. And the concrete on the left-hand side is the prepared concrete, and you can actually see the shape of that.
So that's what I was saying.
MR BOULDING: That's what you were saying. Okay.
Now, Dr Glover, the process will be that various of the lawyers in the room have declared an intention to ask you questions, and it starts with my learned friend Mr Pennicott in the front row, and after that questioning it might be that I ask you a few further questions, and of course the Chairman and the professor can ask you questions whenever it takes their fancy.
WITNESS: Okay.
CHAIRMAN: Good. I think it's 20 to 4. 15 minutes.
Dr Glover, you have heard other people being warned that when they are giving evidence, they remain an island unto themselves.
WITNESS: Okay.
CHAIRMAN: You are not permitted to discuss your evidence at this stage.
WITNESS: Okay. Thank you.
(3.37 pm)
(A short adjournment)

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(3.56 pm)
MR BOULDING: Dr Glover, just before Mr Pennicott starts, there's probably one other matter that I ought to clarify with you. Could you go to page 9 of your report, in ER1, tab 6. Yes, that's exactly that page.
In paragraph 7.2, you refer in the first sentence to various tests carried out by MTRCL. Can you tell us what that's a reference to?
A. It's my misapprehension, really -- sorry, misappreciation. I thought MTR had commissioned those tests but it seems it was BOSA that carried them out. So I'm afraid it was me got it wrong.
MR BOULDING: Thank you very much.
COMMISSIONER HANSFORD: Sorry, are these the CASTCO tests?
A. Yes, that's correct.
COMMISSIONER HANSFORD: Okay.
Examination by MR PENNICOTT
MR PENNICOTT: Dr Glover, good afternoon. My name is Ian Pennicott, I'm one of the counsel to the Commission, as I expect you have either worked out or been told. I did have a few questions for you but those few have been reduced even further as a consequence of your very helpful presentation, for which thank you, and indeed thank you very much for coming to give evidence to the Commission.

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However, could I just take up a couple of points with you. First of all, right at the end of your presentation, the very last slide, you had the "Way forward".
A. Mm-hmm.
Q. You will have seen, I think, in Prof McQuillan's report that one of the recommendations that he makes and is in favour of, going forward, is a system of fairly sophisticated monitoring at the station. Is that something that you would go along with?
A. I would go along with it, because I think that's what is expected. As a personal approach towards such things, I never embark upon monitoring anything unless I understand what I'm going to get is going to be meaningful, because there's no point. So I understand there's two perspectives to this. One is: is it needed? And from a technical point of view, not. From a public perception, then I think the answer to that must be a resounding yes.
Q. Right.
A. But I think it's important that all parties involved, including the public, understand that it's very likely that what they'll get is noise, because it won't move, and the trains, as I've explained, run on the diaphragm wall. So I'm not sure what you would be measuring, and

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to be honest the degree of movements that you will be getting, the particular equipment that you would need to use has to be thought about very carefully, because it's not like having a sight line and a classic measuring device. The movements are that small and you always run a risk when you start a programme such as this that people will say the system is wrong, something must be moving. So I would suggest that if you do do that, and I think I can understand the reasons for it, you've got to be very frank with the public at large not to expect to get daily or weekly or monthly readings which show anything at all.
COMMISSIONER HANSFORD: So it's an assurance?
A. It's an assurance.
COMMISSIONER HANSFORD: You said all you are going to get is noise. In this context, what do you mean by "noise"?
A. Noise in the readings. Everything has got a plus and minus about it. You get a fluctuation naturally. So, therefore -- I could be proved wrong, life is like that, but my appreciation of the issue before us -- you've got something of the order of in excess of 90 per cent of the weight, so --
MR PENNICOTT: It's already there.
A. It's already there. So what's going to disturb it to the extent that you will get anything meaningful out of

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it?
COMMISSIONER HANSFORD: Are you saying any movement has already happened?
A. Not any movement. You could get a crowd of people sitting on the thing, but at the moment you've got something like 90 units. If you put all the people on the platforms and brought the trains in, you've got another six. So that's the proportion. So you've got something less than 10 per cent of the full loading to go and probably less. With that as backcloth, a 3 metre slab has a lot of inertia.
All I'm saying is by all means do that because people will expect it, but please don't expect anything from it, and expect people to query why you're not getting anything from it. That's all. Does that help?
MR PENNICOTT: That's helpful, and you'll be pleased to hear that broadly accords with what Prof McQuillan thinks as well.
A. That's always a good thing.
Q. Can I just follow up by asking you this. You pointed out again in the "Way forward" slide that Ove Arup and Atkins, I think, are carrying out stage 3 of the holistic study which I think is some sort of retrospective analysis of the structure.
A. Yes.

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Q. Will that study, that stage 3 element, in any way inform what future monitoring or similar needs to be done, or are the two things completely unconnected?
A. I think the two things are separate. I'm just pondering whether -- I think that analysis would give you, in fact will give you, an indication of what those fluctuations might be, and I think that could inform the mechanism or the means by which you -- the sort of instrumentation that you could install.
It certainly could give you an indication of that. The models will be good enough to give you an understanding of what the likely deflections could be in the future.
Q. Right. That's helpful. Thank you very much.
Could I then ask you to be shown -- possibly easiest on the screen -- a page in the opening-up file, that's OU, and could we go to 338, please. And could we blow that up.
I imagine this is something you've been looking at --
A. Yes, it is.
Q. -- like the rest of us on an almost daily basis, Dr Glover.
In terms of safety, which of these results, to your way of thinking, are of relevance and importance?

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A. Well, they are all relevant, because they add to a statistical story, so every single one of them is important.

But there are two rogue values, and what I mean -- "rogue" could be taken in statistical terms incorrectly, meaning they are incorrect and tampered with -- but no, the 6.22, and there's one further on, 9.4 at 22, and 6.22 at 5 -- they did surprise me slightly, but the rest are pretty tight, in terms of -- I know we argue about millimetres, and we see them -- the problem with millimetres is they end up with a large number when you record them. I mean, 40 sounds a big number, you know, and the difference between 40 and 38 seems to be huge, but actually these are minute measurements, and I do know how these are put together, because you use the electronics to measure the engagement, but the bit outside is measured by a tape, and tapes are notoriously inaccurate. In fact it's a straight tape.

Because it is a crime scene, the operatives haven't been able to get back and -- because I want them to check that particular measurement using a steel gauge or something -- so although I'm very happy with the measurement that's been taken by the ultrasonics, I would put a bit of a health warning on some of the tape measurements because what you are seeing there is

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a combination of two things.

I'm not saying the results would be vastly different, but it would just give that little bit of precision, and it might answer some of these questions about the odd millimetre here or there, because when you are measuring with a tape, to be able to measure a millimetre, good grief, you've got to take the hair out.

That's why I'm just a bit sceptical about the tape part of it all.

Q. I understand, and I have some difficulty understanding the logic of a 3 millimetre tolerance one way or another when you are going to 0.02 --

A. Absolutely.

Q. -- on the engagement length, but no doubt there's an explanation for that.

What I had in mind with my question earlier is if you go down to 21, for example --

A. Mm-hmm.

Q. -- we can see that the purpose for which that opening-up has been done is purpose (ii), which is malpractice, if you like, just to give its label.

A. Mm-hmm.

Q. But it's an opening-up, as we can see in the bottom bar, the BB, of the EWL slab, which as I understand from your

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evidence, the bottom bar or bottom rebar or bottom mat is always in compression.

A. Yes.

Q. And indeed, taking an extreme position, forgetting about compliance with the codes, none of that rebar is actually necessary.

A. Well, I would like to say some of it would be nice to have around, but no. You are probably looking at something less than a third.

Q. So when I say in terms of safety, on one view it might be thought, well, it doesn't really matter what's there, in terms of absolute safety?

A. Yes, absolutely.

Q. That's something you would agree with?

A. I would agree. The phrase "so what" comes to mind.

Q. Okay. In your report, if we could just go to that, please, with the tests in the back of our minds, could I ask you, please, to go to paragraph 8.2 of your report. That's at page 10, ER, tab 6.

A. Yes.

Q. You say there:

"The allegations of cutting of threaded bars had to be investigated to allay concerns about the extent of such malpractice, but that should not obscure the fact that such malpractice would have to have been on such

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an unimaginable industrial scale and, in addition, focused in specific areas, to have any effect whatsoever on the structural integrity of this construction, particularly in terms of making it unsafe -- which it is not."

Pausing there before the question, if you go then to paragraph 10.5 of your report, at page 14 --

A. Yes.

Q. -- you say:

"On the basis of the evidence supporting the structural adequacy and safety of the construction, there is little case for opening up the structure beyond obtaining sufficient samples to statistically gain confidence that such widespread/wholesale illegal cutting has not taken place."

Do you think we have reached that point yet, Dr Glover?

A. Yes, I think you most certainly have, because subject to going back and measuring -- the measurements which have been done by tape, getting those checked -- I think you have a very reliable database there, and if you look at them then you would have to ask questions about each of them. But from a personal point of view, I find it very difficult to understand why an operative would want to take 2 or 3 millimetres off the end of a bar. It

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doesn't make sense, to cut the bar and then put it -- there comes a time when it's not plausible.

But I think the answer to your question is: is there a sufficient statistical base now? I would think most certainly.

CHAIRMAN: I think your words were "I would think most certainly"; is that right?

A. Yes.

CHAIRMAN: I'm sorry, it's just that the transcriber who does a fantastic job day by day has put "almost certainly". Let me emphasise yet again I have worked with this transcriber before and she has proved her again and again to be superb, but it's just occasionally something pops up.

MR PENNICOTT: I see she's writing that!

Dr Glover, I did have a other questions for you but you've covered them already, particularly on the elongation test and static load test which I was going to ask you about, but you have dealt with that, and Mr Boulding took you to the photograph I was going to take you to arising out of earlier evidence.

So thank you very much; I have no further questions.

MR SHIEH: There's no questions from Leighton.

CHAIRMAN: Atkins? Sorry.

MR TO: Chairman and Commissioner, I just have a few

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questions.

The first question is our Prof Albert Yeung would like to comment on Dr Glover's PowerPoint and he wants to submit some documents tomorrow before 10 o'clock.

CHAIRMAN: To make certain written comments, you mean?

MR TO: Yes, written comments.

CHAIRMAN: Which would be handed in?

MR TO: Yes.

MR PENNICOTT: Sir, it's one of those situations where I guess either you have decided on a point of principle here and now or you say to yourself it's difficult to make any observations without seeing what's coming, and of course we have absolutely no idea what these observations may be.

MR TO: Chairman, bearing in mind we just received the PowerPoint this afternoon.

CHAIRMAN: Yes, I appreciate that. We've all received it reasonably early. But it was the PowerPoint which is an encapsulation of core matters arising in the report. That's my understanding.

MR PENNICOTT: Yes.

CHAIRMAN: So it's not as if it's something new.

I'm not against that request in principle. I'm just concerned as to how it plays out in process, by which I mean we get -- do we simply take the comments and read

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them, or are they to be argued or are they to be followed by Prof Yeung wishing to then give oral evidence to --

MR TO: No, I think he just wants to make a statement relating to what was stated in the PowerPoint.

(Commissioners conferring)

CHAIRMAN: I think this is what concerns us -- please, I'm not trying to be pedantic or difficult, but then the comments come in in writing, and then is Dr Glover given an opportunity -- he may have finished his evidence this afternoon maybe; we don't know -- and then how does he answer? Does he answer in writing? Because if they are comments made, normally what would happen is that -- if, for example, Prof Yeung was here and he could give you verbal instructions, you would put the questions, there would be an answer, and then Mr Boulding at the very end, if he felt that some point needed to be clarified, could deal with it. So we have a well-tried system. But we are stepping into difficult territory.

MR PENNICOTT: Sir, if I may add just the observation you made earlier, which is the PowerPoints don't go outside the report, and I'm pretty confident the PowerPoints do not go outside the report and I've looked at that carefully. If Mr To was able to say to you, "Look, go to a particular PowerPoint", and say, "Compare that

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PowerPoint with the report, there's a brand-new point in the PowerPoint that's not in the report and we haven't had a proper opportunity of considering with Prof Yeung", then one could see that there might be the basis of an argument for coming back on a new point.

But I'm bound to say I don't see any new points of that nature in any of the PowerPoints of Dr Glover, and it was my concern -- as I'm sure is yours and no doubt everybody else's -- where does this process end? We appreciate there are issues. We've got to bring the experts on in some order. Someone has got to go first and someone's got to go last. That's just the nature of the process.

But as you rightly say, if there were any points that Prof Yeung had about Dr Glover's report, then they could have been made orally by Prof Yeung at an earlier juncture or, as you say, with instructions some cross-examination could take place.

I am a bit reluctant of getting into this process of more commentary on experts further down the line. I just don't see where it's all going to end.

MR BOULDING: Sir, could I associate myself with those remarks? My learned friend is absolutely right, and in accordance with convention what ought to happen is that Prof Yeung ought to give Mr To instructions and on the

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basis of those instructions he ought to cross-examine Dr Glover on the matter. Then, as you have observed, I would then pick up anything that was not clear by way of re-examination.

I'm very concerned if we are going to get some sort of written response which no doubt I would then have to consider with my expert when he comes out of the box and it might even be that I have to say, "Prof Yeung has to be recalled because on the basis of what I've been instructed I now need to cross-examine him again", and this merry-go-round frankly has to stop, there must be fair play, and Mr To must have fair play and it may well be that, with others in the room who want to cross-examine, Mr To could delay his cross-examination until tomorrow morning and take instructions overnight.

CHAIRMAN: I think that's essentially the best answer.

Mr To, I don't want to change the process. It's a process that's well tried in our English and Hong Kong common law system. But I don't, on the other hand, wish to deprive of you putting questions.

Now, it seems to me we are at 20 minutes past 4. We can complete any necessary questions from other counsel if they wish. You will then have an opportunity to take instructions overnight from Prof Yeung, and if the professor wishes any particular matters to be put

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forward and you deem it appropriate to do so, as an officer of this Commission -- because we are all officers of the Commission -- then you can do so tomorrow morning. That will give you an opportunity overnight and you can put the questions and nobody is prejudiced.

MR TO: Mr Chairman, I agree with you, and also the Commissioner, and also agree with Mr Boulding, if I can defer until tomorrow morning to question Dr Glover, that will be much appreciated.

CHAIRMAN: All right. I think we will proceed on that basis because I do appreciate we are talking about a very important core issue here, which is one of safety, and the general integrity of the structures under consideration, and insofar as is reasonably possible you must be given all opportunity to air matters.

MR TO: Thank you, Chairman.

MR CHOW: Mr Chairman, I have a few questions for Dr Glover

CHAIRMAN: Yes.

Cross-examination by MR CHOW

MR CHOW: Good afternoon, Dr Glover.

A. Good afternoon.

Q. My name is Anthony Chow and I represent the government.

First of all, I thank you for the presentation. To me, it's very -- actually, it's intellectually

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stimulating. Originally, I prepared four pages of questions for you, but having heard your presentation a lot of them actually are gone.

First of all, I also appreciate that you took the trouble to address the government's concern in relation to COWI's calculation. We do appreciate that -- this morning, maybe, when I explored with Mr Southward regarding that particular load case number 5, which according to COWI's analysis result shows significant sagging moment along the east side of the diaphragm wall.

A. Understood.

Q. We also appreciate that the combined loading together with the superimposed -- the rest of the loading, the final -- the resultant moment is hogging.

A. Yes.

Q. The reason why we still ask the question and we still explored it with Mr Southward is because we want to make sure that there is no problem with the modelling, and we need to understand why, for a particular load case, we have this result, having a sagging moment all along.

A. Yes.

Q. Our concern is the gradient of the change of the moment over a very short distance, less than 600 millimetres, because we know that the overall thickness of the

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diaphragm wall is 1.2, according to COWI the moment at the middle of the diaphragm wall is a hogging moment.

A. Yes.

Q. On the surface of the diaphragm wall, which is at the maximum 600 millimetres away from the centre, it has changed to a sagging moment, and to us the gradient of the change is very substantial, and that poses a question as to the propriety of the modelling used, and this is the government's primary concern and that's the reason why we raised the question earlier.

A. Yes.

Q. In relation to that particular concern, does it appear to be strange to you as a result of the analysis?

A. I have not looked at the detail of the gradient that you're looking at, so I don't feel as if I can give you the answer, but the point I'd like to emphasise is the understanding between us that basically that model that they were presenting was a simply supported model.

Do you understand that? Shall I just draw it?

Q. A simply supported model?

A. Just for the -- I don't want to extend the conversation.

Q. Sure.

A. But I think a diagram is always so much stronger.

I think it also answers your earlier concern.

When we do the analysis of a structure such as the

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station box, it's a composite of different models. There's not one model. We have to get different effects from different models. And the bending moment, the hogging at the supports, comes from the Plaxis analyses, the ones that model the soil and the wall.

So a Plaxis model would look like this (drawing with red marker). That's the NSL slab and there's the EWL slab. But to get to that stage -- and there's the soil -- we do a stage-by-stage construction. So the first stage -- and Prof McQuillan will show this, I think; he's got a number of slides -- so that slab is cast on the ground, and then we excavate it, and this model is modelling each one of those stages.

So the Plaxis model gives us the bending moment that we apply at that point (drawing an arrow), but it doesn't model the slab. All that it gives us is the input at the end.

So what we do to model the slab is we do that (drawing a second diagram), and that's what we call simply supported. I think you know that; yes, of course you do.

Q. So apply the bending moment, that's Plaxis?

A. That's right. So what you do -- there's one load case, which I guess in this case is PERM 5, you've referred to it, and that ends up the bending that looks like that

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(drawing on the whiteboard), but then the other load, which is coming from Plaxis, has another bending moment, and it looks probably like that. You notice this is on the top of the line and this is underneath.

Q. Yes.

A. So if I then take another blue line and I hang this from the top (drawing with blue marker), I end up with a resultant moment which is that, that and that.

So it's two models which create two different inputs, and we add them together, and that's the way we do the analysis. So that's really why, on this case, you get a very steep gradient there.

Now, the steepness of the gradient depends on what the loading configuration is. For example, if you put a huge loading at that point (drawing blue arrow), you most certainly do get a sharp piece, and I think that's probably the way -- the model of the train loading, I'm guessing. I don't know if Mr Southward knows that. But I have not looked at the detail of the model but that is the principle by which they arrive at it, and I think the point you are making is the gradient on this model, which is the simply supported model, and a very large train loading put at that point (indicating blue arrow), would certainly steepen the gradient.

Q. But to be able to explain the result that is shown on

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COWI's analysis, perm 5 has to be a combination of both loading that you have drawn; right? Because according to COWI, at the centre of the diaphragm wall, the moment there, the hogging moment --

A. There's always a problem at the boundary conditions, and that's what we lop -- we call lopping it, like chopping a tree -- because this support here (indicating), if you look at it, if you magnify it, that is a plan -- you are looking at the top of the diaphragm wall, and this is the centre line, so although this is a wall, we model it as part of the slab, generally. So you end up with this area -- because you want to make sure you've got equilibrium so you've got to take them to the centre. But this bending moment here, so if you superimpose the bending moment down here, it's doing something like that, I should imagine (drawing with blue marker), and that's why you are getting this little bit of hogging, but actually, if you lop it, you are all right.

I'm afraid in any modelling in life, there's always a little bit of correction, but we understand that, and equilibrium is maintained. So that's why you get -- please, I haven't looked at the analysis in detail, but I can understand what you are describing.

Q. Neither do I. I guess that's as far as I can go on --

A. I'm sorry, that's about as far as I can go.

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Q. The next area I would like to discuss with you is -- just now I heard you explaining to us, as a layperson, about the water pressure. You mentioned about 15 metres in water pressure acting upwards on the underside of the NSL slab.

15 metres deep of water pressure is almost equivalent to maybe 5 metres thick of -- the weight of a 5 metre thick slab?

A. Absolutely.

Q. Now, the thickness of NSL slab is only 2 metres.

A. Yes.

Q. Whereas the thickness of the EWL slab is 3 metres.

A. Yes.

Q. As a matter of common sense, to me, a layperson, the bending moment for the NSL slab is more critical than the bending moment at the support of the EWL slab, because we don't see 5 metres thick of concrete sitting on top of the EWL slab.

A. No.

Q. And the EWL slab is much thicker, at least 50 per cent thicker than the NSL slab.

I remember somewhere in your report you also mentioned that the underside of the NSL slab, I mean the bottom steel in the NSL slab --

A. Yes.

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Q. -- is always in tension, because --
A. Only at the supports.
Q. At the support, yes.
A. Yes.
Q. And it's also at the support that we have these coupler connections.
A. Correct.
Q. At the moment, the experts -- I think my impression is there's not much coverage talking about the couplers, the criticality of the couplers at the bottom steel -- at the interface between NSL and the diaphragm wall.
A. Yes.
Q. If what I have just described is correct, then the effectiveness of the connection by the couplers between the bottom steel of NSL slab and the diaphragm wall is an important matter that we need to look at.
Now, I believe that it is indisputable that they are not accessible for us to look at the workmanship.
A. Mm-hmm.
Q. I also believe that that is one of the reasons why we have this opening-up exercise at various locations.
The government engaged experts in statistics and the government was advised by those experts as to how the opening-up work should be carried out, so as to get representative data to reflect the quality of the

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couplers.
A. Mm-hmm.
Q. If the quality of the couplers at the NSL slab is so important, which I believe that you agree with me, at least up to this point, and there is no way that we can open up any of the couplers at the bottom of the NSL slab, do you agree with me that to be able to have a more representative picture of the quality of the couplers in the NSL slab, we need to continue with our opening-up proposal or scheme or whatever?
A. Is that your question?
Q. Yes.
A. So your question is --
Q. Yes.
A. I will try not to make the answer long. The slab is not resisting all the water. The water is pushing on the slab, but the slab is doing -- in fact, it's getting support from three different locations. That's why I said the structure has two lives. In the first case, the EWL slab is spanning on its own, and as you say the 3 metre weight is only going through to the diaphragm walls.
Q. Yes.
A. When you've constructed the NSL slab, you build walls and columns up to the underside of the EWL slab. Is

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that something I've got to draw?
COMMISSIONER HANSFORD: No, no, no.
A. So therefore the NSL slab, although it's being subjected to this water pressure, it's being supported by the diaphragm walls on either side, the upthrust in the middle of the spans is being taken up to the EWL slab, so they are sharing the load together, so you are mobilising the 5 metres, and in addition to that there are secondary -- we call them barrettes in the middle of the span, and that's also anchoring it.
So when you add all those effects up, the actual -- let's call it the bending moment rather than getting into sagging and hogging -- you know, the upward bending moment at the support is quite modest, the utilisation levels there, and we've got to do the analysis to demonstrate this but they are not going to be high. So that's the first thing.
I did take account of that in my statement, that I think the structure is safe, you know, with full recognition of the fact, the vulnerability of that.
The second thing you've got to remember is underneath the NSL slab, there's a very substantial waterproof membrane sitting underneath. So it's not as if -- you know, water does leach through to some extent, but for those of you who understand metallurgy, you

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think about rust, everybody gets concerned about rust, but the interesting thing about rust is it needs three components to take place. It needs iron, it needs water, and it also needs oxygen. And so if you don't have all three of those, you don't get rust. That's the first thing.
So if you are in an environment where the level of oxygen is quite low, and I would think 15 metres down in the ground, without recharging of water, oxygen is quite low, so the risk of high corrosion from water is very low. The second thing is if you ever got a crack pattern, the crack pattern wouldn't run along the bars, it runs across the bars, and all the research shows that actually that is the least risk.
So to answer your question, the utilisation levels of that structure are lower than you think because of the supports it has. It's got a waterproof membrane underneath it, and looking at the photographs, I didn't see it myself, but I can vouch from the photographs that it's there, and the risk of actual cracking and corrosion at the stress levels we are talking about is very, very low. That's my answer to you.
Q. So I guess someone has to at least run the numbers to work out the --
A. The utilisation level, yes.

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Q. And unless, having done that calculation, and we are satisfied that the bottom steel of the NSL slab is always in compression, as in EWL slab, the effectiveness of the coupler --
A. No, sorry. I didn't say that the bottom of the slab would be in compression. It will be in tension, but it will be at a lower level than you suspect.
Q. Yes, I fully agree with what you mean.
A. Sorry, I thought you said --
Q. What I'm trying to say is unless having run those numbers and coming to a result which shows that the bottom steel is always in compression, otherwise the effectiveness of the couplers is still an issue that we need to ensure that at least it won't be too bad; is that right?
A. I'll answer two ways. First, you did say compression again of the bottom couplers, and I'm saying to you they will be in tension on the bottom. They will be in tension, but the level of that tension is very low.
Q. So long as it is in tension, do you agree that we need a proper connection --
A. Of course you do.
Q. -- to resist that tension?
A. Right. So we are agreed now that it's in tension at the bottom.

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Q. Yes.
A. And I'm saying to you that the utilisation level is very low, because of the reasons that I've explained, which it's got multiple supports. So we agree that it's in tension and that I believe the utilisation is low.
So then let's move to what is -- what do we expect to get from the opening-up? I would say, with the samples as they are now, probably about 84, you will not find -- and you can speak to as many statisticians as you like; I am not an expert in statistics but I use them -- you will find the trend is already set from the figures we have, and the fluctuation -- let's say, you know, arbitrarily, that something is coming out with a projection of 10 per cent at the moment. Then I think if you take another 84 or whatever it is samples, you will find that will fluctuate between probably 8 per cent and probably 12. It won't affect what we will do, because whatever we get from the results from the study, we will take a conservative view.
Let's say our utilisation levels are 60 per cent, then we will not necessarily use 60 per cent in our analysis. We will use something much more conservative.
So my answer to you is you've got -- you, we, the world has got -- sufficient statistics on the potential of something being 32 millimetres, 34, 37. It isn't

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going to get better. So if you do another 84, they are not going to change that percentage by very much. And clearly you will, I guess, speak to a statistician and see whether what I'm saying is correct.
Q. Yes.
A. There's always the possibility you are going to find this black hole somewhere, but no, not with something like this.
Q. Just for your information, according to the latest opening-up result up to I believe yesterday, at the moment, if we apply the passing mark of 37mm -- I appreciate that MTRC is going to carry out extensive tests and then perhaps at some point we need to review this passing mark -- but at the moment, on the basis of the information available to the government and to the public, we have recommendation from the supplier of the couplers, and at the moment the passing mark is 37mm engaged length.
On the basis of this, at the moment the result is that almost 49 per cent of the couplers exposed failed.
A. You mean in terms of the total sample?
Q. Yes, that's right.
A. In other words, 49 per cent of the planned number have been exposed.
Q. Yes. This is the situation that the government is

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facing at the moment.
A. Yes.
Q. If at some later point in time we can adjust, if there is justification to adjust the passing mark, then of course people will review the situation, but on the basis of what we have today, with 49 per cent failing --
A. No, no, no, I'm sorry. I misunderstood your earlier statement. I thought you were saying that of the planned opening-up, you were 49 per cent. That's not what you meant; is that --
Q. 49 per cent --
A. Or are you saying 49 per cent of the readings have failed?
Q. Yes, 49 per cent of the samples with the reading that failed to pass the 37 millimetres passing mark. This is the situation at the moment.
A. You see, we have a problem there, don't we, because I don't recognise your number so we are going to be talking about statistics from two different points. I see no reason whatsoever to accept the 37 and I'm not giving that statement in the absence of any knowledge. I fully expect a screwed fixing of any type to behave such that you would get its full strength at something much less than 100 per cent. So the idea you stick to these higher numbers, personally I can't support.

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Q. May I just make a correction, I do apologise. I have just been informed that the 49 per cent is a total, including samples from EWL slab and NSL slab. Sorry, 49 is only for EWL slab, but for the total, it's something like 42/43 per cent.
A. Okay.
Q. If you only look at the sample taken from NSL, actually the percentage is about 20 per cent.
A. Okay.
Q. At the moment, this is the position at the moment.
A. And are they better or worse?
Q. Well, 20 per cent of the sample exposed fails to pass the 37mm requirement.
A. Yes.
Q. With that level of non-compliance -- I put it as non-compliance --
A. I like that, yes.
Q. -- do you think this gives rise to any concern as to the effectiveness or the safety in relation to NSL slab, assuming that we have 20 per cent of the couplers?
A. No. When you look at a statistical issue, you ask yourself the question: what are the parameters that will make it vary? So if you are looking at workmanship of a coupler, you would be looking at the workforce, the materials they use and the conditions they are working

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under, and there is no distinct difference between the EWL and NSL. So they are all part of the same family, as far as I'm concerned. I don't differentiate between the NSL family and the EWL family. They are all one family.
Now, statisticians might disagree. They might say the NSL represents a different family. But then I'd ask them why, because I don't see it.
Q. I see. So according to you, you will take the overall percentage --
A. Correct.
Q. -- as representing the level of -- representing the overall condition in NSL as well?
A. Absolutely.
Q. So if the overall percentage is 30, for example, just for example, if the overall percentage is 30, 30 per cent of the couplers fail, then you would infer that 30 per cent of the couplers in the NSL also fail?
A. That would be a conservative view, but that's one I would stand by because it gives you -- I believe it would give you a conservative view, and the reason for that is operatives get better as they do the same operation time and time again, and so therefore I would expect the readings to be better on the NSL than they are on the EWL.

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But I would still stand by the same statement that I think they are part of the one family.
Q. Dr Glover, just now -- I'm moving on to another topic -- I heard you mention you said you look forward to looking at the calculation for the construction joints.
A. Mm-hmm.
Q. Can I take it you are also of the view that it is appropriate to carry out checking of the internal stresses inside the connection; right?
A. I think if a professional person raises a legitimate issue, then it has to be considered, and so, you know, with that as a context, then yes, I think it's the proper process to go through. I think the anxiety I have is that it takes so long to do it.
It is not -- it is a calculation which can be simply justified as Mr Southward indicated, and you reach a situation sometimes where if you can demonstrate something at such a sort of in-principle level, then you don't dig down constantly. You don't keep looking for the black hole that's in there. You know, maths is maths, and the calculation yesterday that Mr Southward showed just took into account part of the system that holds that together, and he demonstrated, I thought -- I haven't looked at the calculations but it seemed very rational to me -- that that in itself dealt with the

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problem.
But if you think, "No, we don't want to include that, we've got to do something else", then there's lots of other mechanisms in that joint which give me the assurance, without doing any more numbers.
But if that doesn't pacify everybody then you have to go the extra mile. I would rather we didn't have to, that's all. So be it.
COMMISSIONER HANSFORD: Is the reason you would rather we didn't have to because you don't think it's necessary?
A. Yes. I abhor wasted effort, but sometimes you've got to do it, you've got to go that extra bit, and if that is what the Commission believe is the thing that puts it to bed, then so be it and I would support that.
MR CHOW: I am happy to ask my last question now, but can I refer you to paragraph 4.6 of your expert report, at page 4, please.
The fourth bullet point.
A. Yes.
Q. Where you said:
"Due to the disproportionately stiffer and stronger EWL slab ... relative to the diaphragm walls ..., it would be impossible to develop ductile behaviour in the slab or its connection to the walls since the wall would have failed structurally under ultimate load conditions

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long before the rebar in the slab would have reached its yield stress ..."
Do you see that?
A. Yes, I do.
Q. Am I right in thinking that for this statement to be true, there is a prerequisite which is the connection has to remain intact in order to transfer the load down to the diaphragm wall?
A. Yes, I would accept that, basic physics.
Q. So for that purpose one has to check the stress inside the connection to make sure that it works?
A. Yes. Mr Chow, I've accepted the principle that the calculation has to be carried out to satisfy everybody.
MR CHOW: Thank you very much, Dr Glover.
I have no more questions.
CHAIRMAN: All right. Good. Thank you very much.
Mr Connor?
MR CONNOR: I have some questions, if I may, please. Given the hour and the estimate of time which I have already given Mr Pennicott, I will not finish today but I'm very happy to start, if you would like me to do so.
COMMISSIONER HANSFORD: I think so, yes.
MR CONNOR: Or I can defer it entirely and start in the morning.
CHAIRMAN: We might sit just a little bit later. What is

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our normal time? Sorry, I know I have interrupted the normal time recently.
COMMISSIONER HANSFORD: We no longer have a normal time
MR PENNICOTT: Normally 5 o'clock, I think. I don't know how long Mr Connor is going to be, but if we could make some progress, and you are happy to sit a bit later, unless anybody else has a problem.
CHAIRMAN: We do have to rise by 5.30 and I appreciate the day is draining on a lot of people, intellectually as well as physically. So let's go through to until 5.15, shall we?
MR PENNICOTT: Yes, sir.
MR CONNOR: Thank you. I'm very happy to do so.
Cross-examination by MR CONNOR
Q. Good afternoon, Dr Glover. I'm Vincent Connor; I represent Atkins China.
A. Okay.
Q. I have a few questions for you this afternoon, picking up on I think a couple of points which have arisen this afternoon and also dealing with some points in your report which you have produced as of January 2019, but also referring back to some earlier work which you've done in relation to the holistic study.
A. Okay.
Q. Thank you. As you have gathered from the Chairman and

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the professor, I will get some way along the road this afternoon, but perhaps, with approval, we might resume in the morning if need be.
Perhaps just starting with your experience and credentials that you shared with us earlier on. You told us very helpfully about perhaps one of your earliest experiences in Hong Kong and in particular in relation to the HSBC headquarter building --
A. Yes.
Q. -- and that by a rough measure would have been sometime in the 1980s.
A. Started in 1979.
Q. There we are. Thank you. But I take it that you have, therefore, over the time since that particular project, had a level of involvement in Hong Kong projects? It's something which has been part of your professional life since then?
A. No. When I finished the Hongkong Bank, I didn't have any further involvement. I mean, clearly I come to Hong Kong to speak to our people and give them lectures.
Q. Yes.
A. My only other involvement was with MTR from 2013 through to about 2015, as part of the international expert panel review, and there were three others. There was myself, John Burland and Alastair Biggart -- Alastair was

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tunnelling, John was geotechnics and I was structures, and we looked at -- we came for a week, on about six-monthly intervals and we looked at about three projects a day. We just were given a briefing and gave our comments on a Friday afternoon and then we went back again.
So there was no deep research in it, but we looked at particular issues and problems.
Q. That's helpful, because I think that gives us a flavour of, shall we say, the continuity of your involvement in the thinking and consideration of projects in Hong Kong, and, I think as you have said, arisen in the way that you just described and no doubt in the activities that you have within Arup that brought you to Hong Kong over the time.
A. Yes.
Q. And you made a comment I think in response to questions from Mr Boulding earlier, but it may have been part of your presentation, where you talked about, in Hong Kong, that there is taken an extremely conservative view, and that I think you were applying to the question of ground parameters at the time, but I think it's one that you extended into a view of prudence on the part of certain government authorities.
A. Mmm.

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Q. Do you recall that?
A. Yes. I mean, I don't recall your particular words, but let's see where you want me to go with that. I didn't use those particular words.
Q. My apologies.
A. It's okay.
Q. It's a rough and ready --
A. I speak fast.
Q. -- 4.50 pm attempt to capture your theme.
But we understand, or does one understand, from your comment that those who are designing permanent works in complex infrastructure projects in Hong Kong clearly have to interface with those who are empowered by statute to review and approve those submissions?
A. Yes.
Q. And is your reference to prudence and conservatism on the part of those who approve something which is part of your evidence to this Commission?
A. Yes. Crumbs -- how much time have we got? No, this was not -- my words were general, observational. Remember, when I did my reviews with MTR -- and interestingly enough none of them were on this station, none of them at all -- but I found certain illogicalities in the thinking that had been applied to particular situations, and I just used the ground one here because I know that

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was how the station was designed, and I found that it wasn't the calibre of the designers that was the problem. They were under severe stress in terms of getting things done, getting designs out of the door. And so, in that context, they were following the rules, and it would have been a brave man to fight against those rules because I thought Prof Au's description of the particular process you would go through for change actually painted a very stark picture, for me anyway, of the fact that they might be guidelines but the reality is they are mandatory, and if you are a professional in Hong Kong, a designer, then I think you would learn that very quickly and you would stop asking the questions, and hence that's why in my statement I use the word "unquestioning", not because the individual isn't capable of doing it, it's because the process would have resulted in him not being able to deliver what he has to within the time scales that are set by certain programmes.
So it was not an assault on any particular individual or firm. It was a general statement, and a fear, because an environment that doesn't recognise -- an environment that relies upon rules kills innovation. It kills off questioning. It kills off the very life blood of what engineering progression is all about.

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That's all I'm saying. And more and more in the Hong Kong Code I see these rules coming in, like the one I talked about with ductility.
For the life of me, why does someone have to write a clause like that, which is very precise in what it asks for, when actually, if you stand back, you think, well, all reinforced concrete, if it's designed in the way I said, where the tension/reinforcement governs, is naturally ductile. But you do need these special requirements, and they are special, when you've got particular situations where you need high ductility, like the ground movement I was talking about.
But really, the way the rules are written, you don't have an option as a designer. That's what you've got to do. And I'm saying that doesn't make sense in my world. But I live in a different world.
Does that help you?
Q. It is very helpful indeed, thank you, because I think what -- again, if I may play back to you what I understand you to be telling us -- it's that given those rules, that rule book, and the way in which therefore, as a designer, one must approach matters, then there's an inevitable observance and understanding of what the content of the rule book is and what the likelihood is of, shall we say, those rules being flexed

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or otherwise relaxed.
A. Well, Galbraith would have called it the conventional wisdom. You know, after a little bit of experience, society gets a conventional wisdom, and they are the rules by which you live. And if those are the rules that you live in, then I'm coming from a different world, a different environment, and if I see differences then I feel that professionally I should identify them, because I do think they have bearing on issues. I don't think they are isolated from the particular issues we have on this project.
Q. Thank you.
Against that background then, and as you will gather and I think as I've shared with you, I will come to look at some parts of your report, and also the report which you did in November last year.
A. Oh, I see, the actual reports themselves, the Arup reports, yes.
Q. Indeed. That may be tomorrow, subject to the Chairman and the professor.
A. Okay.
Q. But just again to flesh out one's understanding of the approach then of the designer in Hong Kong to the way in which design needs to be put together to, shall we say, have the prospect of acceptability and progress, I have

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a few areas which I want to ask you about, and I don't intend that they are exhaustive, but they might be instructive.

The areas are really this, that when the designer is going through his process, putting together the permanent works design, on a project rather like this one, let's say the Hung Hom Station box design, he's going to have regard to the particular circumstances and nature of the project itself, the complexity of the project; safety --

A. Mm-hmm.

Q. -- programme, no doubt; and also things like the temporary condition of the works and what he has to build into the design to cope with the temporary condition before it gets to the permanent condition.

You may add others to that list, but that as a group of considerations would seem to you to be a sensible series?

A. Yes.

Q. Am I right in understanding, then, that as a designer of such permanent works, having regard to what it is that one is putting together -- and we have spoken about reinforcement, for example, the extent of reinforcement one builds in -- you would be having regard to those five areas that I mentioned with a view to assessing not

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only what the job needs but also its likely acceptability to those who will have to approve it? Would that be fair?

A. I think, unfortunately, that does appear to be the case.

If I could help you slightly.

Q. Yes.

A. And I think it is a very good discussion, actually, and I don't think the commission really is set up for discussion, but here goes.

I mentioned two very large projects, really. The governance structure in both of those projects is extremely shallow. The client, for example, on HS1 was only 50 people. They were the approval authority. We did everything else. It was an EPC contract -- engineering, procurement, and construction management -- so we were responsible for everything, all the engineering, all the procurement or whatever. And alongside us, we had a checker, who is an independent engineer, independent organisation. And by "checker" we don't mean line checker. We are talking about the basic principles, the key principles.

We would agree between us what that design basis was, which the codes were going to be, agree those with the client, and we would progress. If we found, as designers, that we saw something which we could improve

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upon, we would discuss that with the checker, and, if we both agreed, we would literally go and see the client. We wouldn't send something through the post, because -- it's this immediacy. It's this sense of one-to-one communication. It's not ten-page letters going backwards and forwards to each other, which slows the process down.

Just think how long it takes to produce a ten-page letter, and then to go through it time and time again.

So the process is entirely different. The client has authority and responsibility. If I look at -- and I am probably exceeding my brief here but -- in fact I am exceeding, I guess, but I will say what I say -- there is no proper client on this particular project. There's not a single entity. There's a grouping of organisations that have an interest in the project, but one party has to do everything, has to be responsible for the approvals and the direction of the works for efficient working. You can't go to one part to get approvals and get direction from the other. It doesn't make sense. And if the people that are giving the approval don't have ownership of the outcome, what does that mean? How does my flag on the hill work with that?

Unless everybody in the team is working towards the

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same objective rather than their own protective silo -- that's when things go wrong.

So I've probably exceeded my brief and I've exceeded what the Commission is about, but those are the key issues. That's at the source of what you are sitting around here.

COMMISSIONER HANSFORD: I don't know your precise brief but you certainly haven't exceeded the terms of the Commission of Inquiry, because these go to matters that we are considering.

A. Okay. I hope I've been articulate enough. It was a rather rambling response.

MR CONNOR: Definitely articulate enough. Thank you, Dr Glover.

Sir, if you are happy, I will move on to develop the thought a little.

CHAIRMAN: Of course, yes.

MR CONNOR: We have heard a little bit about your use of the word "conservative" with design. So I guess against the background of what you described to us, in terms of the rule book, the interpretation and application of the rule book, shall we say the range of stakeholders that you've just described to us, all of whom may have a view on whether or not a particular design is appropriate or not -- these are the things that drive a conservative

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and prudent design, because if one doesn't put a conservative and prudent design forward, then frankly it's going to, to use a railway metaphor, hit the buffers somewhat; would that be fair?
A. It would be an interesting -- our experience in the UK at the moment with Brexit is a classic example, really, where --
Q. No, we definitely don't have time for that!
A. It's a classic example where you can't satisfy all the parties, and in the end because someone quite genuinely sets out to satisfy all the parties, you end up with an absolute mess that doesn't satisfy anybody.
COMMISSIONER HANSFORD: I think that is beyond the brief.
A. I know. Sorry, that was ex-censorship. We can delete that from the record.
COMMISSIONER HANSFORD: We do understand that point.
A. That's what I'm saying. You've got to have people who have authority and responsibility. If you have people who have authority but no real responsibility for the final outcome, then you've really got a problem on your hands.
MR CONNOR: So with that -- and I mention those five areas that I at least have in mind for the purpose of looking at influences on the approach to design -- the first of those I suggest to you was the nature of the project in

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question, and I think you do come to say some words on this in your report which I think we might come to tomorrow, but I think you have very fairly shared it with us earlier on in your presentation, that in terms of the nature of this project and approaching the design of it, one would have had to have regard to not only, shall we say, the job in hand, the extension of the station in the form that's been anticipated, but the protection of the existing structure?
A. Mm-hmm.
Q. The consideration of adjacent land and other structures?
A. Yes.
Q. But perhaps in circumstances where the construction types were less certain than might otherwise be ideal?
A. Mm-hmm.
Q. Of course the need to do all of this, that is to design and then to have it built while allowing operational activities in the station to continue -- yes?
A. Yes.
Q. Not to interfere with the transport interchange that also existed at Hung Hom; yes?
A. Yes.
Q. And all of that, when you take it together, as far as the nature of the project, before we even get to complexity, there's a whole bundle of things, big

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issues, that the designer has to take into account at that stage, of bringing the permanent works design together, to ensure that he puts forward something which is going to do the job, but again, having regard to the stakeholders and all the interests and the rules you mention, is articulated in a way that is not going to hit opposition?
A. Yes.
Q. Just to give a flavour of that -- and thank you for your response to that -- if you could have before you just a drawing to illustrate matters, drawing H559, please. That should appear on the screen in just a moment there.
A. Yes. I've got it.
Q. Thank you. A drawing that you will be well familiar with or ones rather like it.
But again, just to emphasise the nature of the project itself, what we see to the left-hand side of the structure as shown in the drawing in shading, as you will see at about the line from the top, K1, and to the left of that, the designer, in approaching this project, would have had to have regard of course to the perimeter walls and the reinforcement of those perimeter walls to minimise the ground movements, to prevent damage to the existing infrastructure, et cetera, around it. So that would be an example of the kind of thing you and I have

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just been talking about?
A. Yes.
Q. Thank you. The second area -- we may come back to that drawing in a moment, or tomorrow morning, if I'm permitted -- was complexity itself of the project, and in particular the structure that's required to be designed.
Again, we have talked a lot this afternoon and on other days about the EWL slab in particular and its very significant proportions in terms of its thickness, et cetera, which you gave us your initial expressions of before. But in some ways, if I might say, and not attributing the view to you, that could be a simplistic way of describing what is actually in itself a very intricate piece of work; would you agree?
A. Yes, I would.
Q. Again, just for illustration, if you could have in front of you H576. This is a view of, amongst other things, that slab itself, and I guess what this might show, subject to your thoughts, is an illustration of the very considerable number of openings, for example, that had to be facilitated within that very substantial 3 metre slab, openings and cut-outs which deal with stairways and services and all sorts of additional requirements that run through it. Would you agree?

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A. Yes. It's heavily perforated, yes. I'm not sure what I'm agreeing to, because you've told me it's got lots of holes in it and I've agreed with you. Is that what you meant?
Q. It is, but I'll take your engineering expression in those circumstances.
A. And you could also add they are at mid-span -- does that help you to put your argument?
Q. It does, because the inclusion of all of those and the demand for all those would have otherwise constrained the spanning capability of that slab, but of course the intricacy with which the work is applied has to anticipate that and deal with it; yes?
That in itself raises, no doubt, demands as to the way in which the arrangement of rebar is allowed for within a structure like that or a piece of structure like that.
A. I think I know where you are coming from. Can I help you to get to what you want? Because, I mean, it's a very nice story, but what is it you want me to say? I'm sorry, I don't mean to be -- I didn't mean it like that but it's getting towards the end of the day and I'm sure I'm going to agree with you but I'm not sure what it is you want me to agree with.
Q. I like your approach. It's a very, very helpful

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approach.
MR PENNICOTT: Dr Glover, if I may say, I think we'd all like some guidance on where all this is going because I have to say at the moment I'm a little bit confused.
CHAIRMAN: I'm just wondering, Mr Connor, all of it is helpful, but I wonder if it's not more helpful by way of final submissions, because it seems to me that what you are putting is self-evident, and not only to an expert but I would imagine to well-informed laypersons. We appreciate it's a complex project. We appreciate that the slab is not merely just a great chunk of concrete, it's something far more complex than that. And we appreciate the dynamics which both help and constrict designers.
So all of that we would be delighted to hear from you within your final submissions, but I don't know that it needs the imprimatur of Dr Glover necessarily, in this area.
MR CONNOR: That's helpful in itself, sir, but to an extent, because of the wording and the opinions which he has sought to apply, which we will be coming to tomorrow, in certain of his opinion and report to you, it is something that one has to address. But it may well be that given where we have got to already with him, one can do it fairly briskly in the morning, because I think

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he has given an indication of a number of helpful observations, and a view that perhaps, shall we say, puts the comments in his report in greater context for these purposes.
COMMISSIONER HANSFORD: I think we should be careful that he hasn't agreed to something you haven't asked him yet.
MR CONNOR: No, absolutely. Perhaps, with your blessing, we might close off on this particular point, sir.
CHAIRMAN: Yes.
MR CONNOR: And then resume in the morning with a view to concluding this number of questions.
If I may, sir --
CHAIRMAN: Yes.
MR CONNOR: You were kind enough to suggest that you might agree, but let us see if you do.
You have agreed that the complexity of a project is something which quite rightly, against the background of the rules of approval, the way in which it may be applied, et cetera, is something which a designer will have in contemplation and consideration when putting his permanent works design together in Hong Kong, and that would apply to the Hung Hom project, and of course this: that it is understandable, against that background -- bearing in mind the nature of the project and complexity of it, the demands for programme and so on -- that

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a conservative approach, which anticipates the likely blockages, views and application of the rules may have in mind, would be deployed?
A. I think that's true. What you are trading there is you are trading, let's say, the efficiency of the design against a time scale, and you've got limited time and you've got some very real constraints on that side, exacerbated by the limitations that have been placed on such constructions, and I mean by that the 25 millimetre displacement or settlement at ground level which in some situations is remarkable in terms of its difficulty.
So with that as a backcloth, yes, you've got to take a conservative view. If you had more time, if you had a more benevolent approval system, then I think you would have ended up with a better design, less conservative, more considered. But within the context of the limitations you had, I can fully understand what you've done, and I've not said anything to the contrary, to the best of my knowledge, maybe; I had to think about that one.
MR CONNOR: Thank you. That's a helpful point on which I might suggest, sir and Professor, we might pause this evening.
CHAIRMAN: All right.
MR CONNOR: And probably as far as tomorrow is concerned,

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I'm estimating something in the order of about 15 minutes or so to conclude matters.
CHAIRMAN: All right. Thank you. It's very difficult. Either Mr To -- I suppose it's impossible for you to know because you don't know what you are going to be instructed.
MR TO: That's true. I was aiming this afternoon for maybe 15 minutes but Prof Yeung does have something he wants me to convey.
CHAIRMAN: All right. May I just give a warning order: we would very much like to finish the expert evidence tomorrow, and depending on how we are going and subject to guidance from counsel, if necessary we would look to sitting a little bit later, if we can clear everything. We are thinking of maybe 6 o'clock or something like that. We are not talking about people sort of having to have supper here or anything like that, but even if it's 6.10 or something but we can clear it all, then all the expert evidence is finished. I'm sure you will agree it's better than coming back at the end of the weekend. All right?
So absent anybody having any particular pressing other engagement, which we will obviously take into account, just bear that in mind. We hope it won't be necessary but bear it in mind.

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MR PENNICOTT: Sir, I very much hope it won't be necessary because the indication is that hopefully Dr Glover will finish his evidence, say, within a maximum of an hour, from indications we have just been given. Obviously that will leave Prof McQuillan to give evidence, and on the estimations that I've received, which are only three, the maximum for the government is an hour and a half, China Tech 20 minutes and Leighton half an hour.
CHAIRMAN: All right.
MR PENNICOTT: So subject to how long Prof McQuillan's presentation is going to take, I would hope we will finish comfortably within tomorrow and well before 5 o'clock. Famous last words.
CHAIRMAN: There is one thing I just wanted to ask before we go. The expert reports contain some very helpful diagrams for myself and for Prof Hansford. I take it that if we wish to include any of these diagrams in our report, there's no -- we're not going to stumble across copyright issues or something like that?
MR PENNICOTT: I hope not.
CHAIRMAN: In other words, I want to be able to purloin as much as I can from those expert reports, where I think it will be of help, including drawings and photographs.
MR PENNICOTT: I hope it's not of concern to anybody, but, sir, since you have raised it, if anybody does have any

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issues with that, no doubt they will tell us.
Certainly for our part, when we have been struggling, despite the endeavours of this week, to progress our closing addresses in writing, we have certainly managed to incorporate some drawings and photographs and so forth into our closing submissions, and I hope -- I'm sure that's all very acceptable. But of course your report is far more important because that's going to be made public in due course.
So if anybody has a problem, no doubt they will let us know.
CHAIRMAN: Thank you.
MR BOULDING: Sir, may I just raise two points?
CHAIRMAN: Yes.
MR BOULDING: Firstly, I wonder whether it's attractive to you to start at 9.30 tomorrow to ensure we finish and we don't have to sit too late.
I suspect you are just about to read the riot act to Dr Glover but those instructing me need to re-arrange his flight home and I wonder whether they can be permitted to speak to him about that.
MR PENNICOTT: Of course. There's absolutely no objection to that.
CHAIRMAN: Dr Glover, in his evidence so far, has said nothing about his flights home, so we will work on the

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basis that's an entirely extraneous matter.
Mr Boulding, of course you may.
MR PENNICOTT: Certainly if we don't finish tomorrow evening, then we will be having to re-arrange Prof McQuillan's flight tomorrow night.
CHAIRMAN: Good. Thank you very much. 9.30 tomorrow? Mr To, that's okay for you?
MR TO: Yes.
CHAIRMAN: Good. Then 9.30 tomorrow. Thank you.
(5.23 pm)
(The hearing adjourned until 9.30 am the following day)

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